POWER PLANT ENGINEERING

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Providing More Power

MODERN FUEL HANDLING EQUIPMENT AND VARIABLE SPEED ENGINES DISTINCTIVE FEATURES OF NEW POWER PLANT INSTALLED AT MILLS OF HUMMEL & DOWNING CO., MILWAUKEE, WIS.

INCREASING DEMANDS for the finished product and scarcity of raw materials have in many instances, and especially during the last few years, been responsible for the introduction of substitutes in the manufacture of some of our more generally used commodities. And in many instances these substitutes have not only proved as reliable and as serviceable as the original material, but have even enabled manufacturers to offer their products at considerably lower prices. Exemplifying this trend of activity in the industrial world, we may cite the ever increasing use of paper for the making of boxes and containers in which heretofore wood or metals have been employed exclusively. As a consequence, mills for the manufacture of the special grades of paper required for such use, and factories for the manufacture of this paper into boxes and containers, have been established in various sections of the country, one of the largest and most recently constructed of these being that of the Hummel & Downing Co., at Milwaukee, Wis.

About 6 yr. ago, the first mill, a structure of steel, concrete and brick, four stories in height and having approximate overall dimensions of 367 by 98 ft., was constructed and placed in operation, but due to rapidly increasing demands for the product, it became necessary last year to extend the original building about 342 ft. to the north and provide increased capacity in the power generating department. These changes included the installation of a number of special engines for the driving

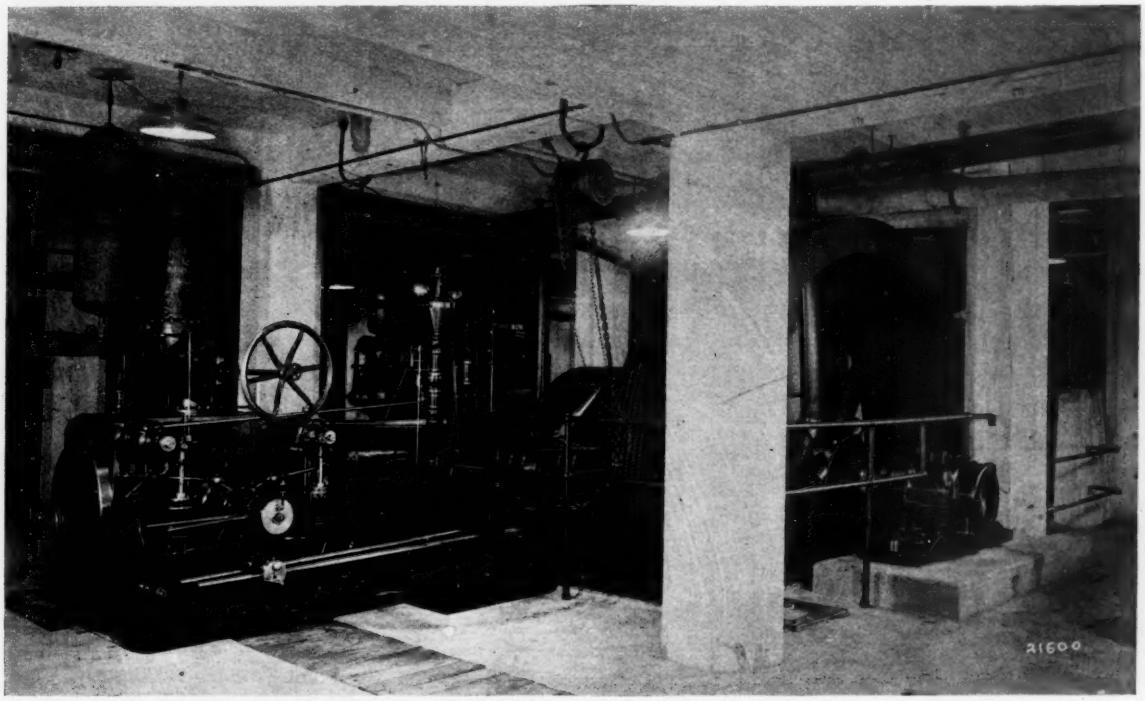


FIG. 1. VIEW IN NEW ENGINE ROOM SHOWING NORDBERG CONSTANT SPEED UNIT

of the new paper making and auxiliary machinery, and the erection of a new boiler house independent of the mill proper and with a steam generating capacity sufficient to meet the demands of this institution for some time to come.

Steam Generating Equipment

At present steam for power purposes, heating and manufacturing processes, is supplied by two separate boiler plants, although one of these, the older, and that located in the basement of the original mill will be cut out of service in the near future and the boilers removed to the new boiler house, the ultimate arrangement of equipment there being as indicated in Fig. 3. Figure 6 pictures that section of the new boiler house already in operation.

Of steel, concrete and brick construction, with architectural lines corresponding to those of the new building and with overall dimensions of 87 by 110 ft., and a total height from ground lines to the roof of the monitor of 59 ft. 6 in., the new boiler house, located across the street from the main mill, is divided into two sections, one of which, the smaller and that of the north end being utilized as a pump and heater room, while that occupying the south end of the building is employed to house the boilers. Here, as illustrated in Figs. 3 and 4 are at the present time installed and in operation six 300-hp. Stirling water-tube boilers equipped with Murphy automatic stokers and set in three batteries of two units each; when the installation is complete, there will be in addition to these, three 300-hp. and one 375-hp. Geary water-tube boilers arranged in batteries of two units each and fitted with the same make of stokers as are the Stirling boilers.

Natural draft is employed in connection with the furnaces. Through the medium of sheet metal breechings having sections of approximately 4 by 7 ft., each row of boilers is served by an individual reinforced concrete stack 150 ft. in height and about 14 ft. in diameter at the base. One of these, that serving the Stirling boilers, rests upon a foundation in the pump room, while the other is outside of the building at the south end.

The coal and ash handling equipment, manufactured by Philip Lang & Co., of Chicago, is most complete, with the result that the labor charges at this end of the plant will undoubtedly be reduced to a minimum. Adjoining the boiler room, and as may be seen by referring to the longitudinal section, Fig. 4, is a combined ash storage and coal receiving tower so constructed as to provide for the ready entrance of gondola cars for the delivery of coal or the removal of ashes. Coal brought to the plant is dumped from the cars into a receiving hopper, whence it is discharged into the buckets of the conveyor which carry it to the 1000-ton reinforced concrete hopper in the boiler room; it is then fed to the furnaces through individual chutes. A crusher, operated by a 15-hp. electric motor, installed so as to receive the coal before being taken up by the conveyor, reduces the pieces to the required sizes; this machine may be placed in or out of service as deemed necessary, thus avoiding operation when the coal is of such size as not to require crushing.

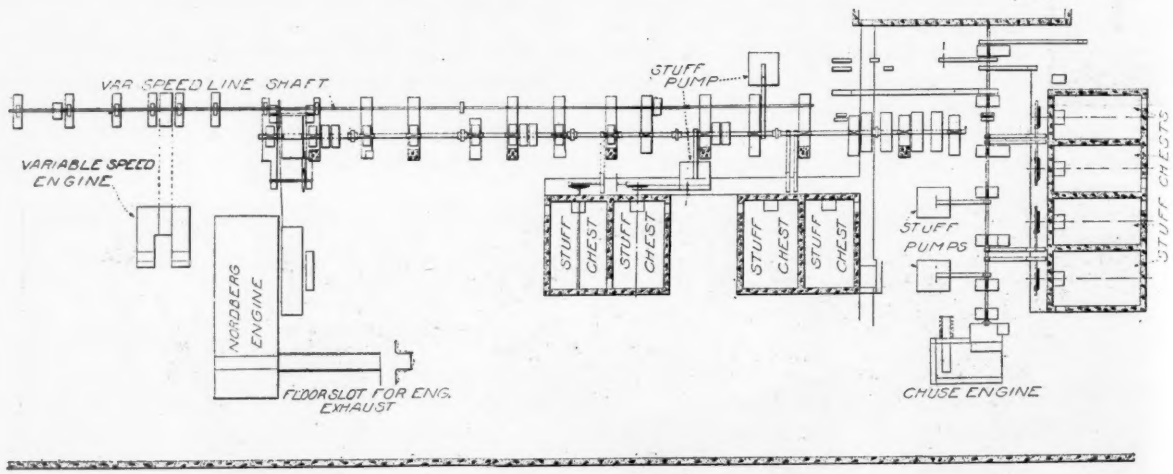


FIG. 2. PLAN OF NEW ENGINE ROOM

From the concrete receiving bins placed below and parallel to the fronts of the boilers as indicated in the sectional view of the boiler house, Fig. 4, the ashes, which drop from the furnaces above, are removed by means of hoes and are allowed to fall through gratings into the conveyor buckets below. They are then raised and dumped from the conveyor buckets into the 100-ton ash tower; thence they may be discharged into cars for removal as required or desired.

Water used for all purposes except drinking is taken from the Milwaukee River, being allowed to flow by gravity through an intake tunnel to a pump well located in the old mill. From here it is pumped by any one or more of three 2,000,000-gal. per day American Well Works and Allis-Chalmers centrifugal pumps to a 13,500-gal. tank on the third floor and from there distributed, that for boiler feed purposes being delivered to a 3000-hp. Moffat feed-water heater, purifier and oil extractor located in the pump room of the new boiler house. The water, heated to a temperature of 212 deg. F., is then fed to the boilers by one of two 200-gal. per

minute Hill centrifugal pumps, each driven by a 45-hp. Waite steam turbine, each of these units is capable of caring for 3500 boiler horsepower. In addition, there is also a 14 by 8 by 12-in. Marsh pump, which while primarily intended for boiler cleaning and general house purposes, may be employed as a boiler feeder in case of emergency.

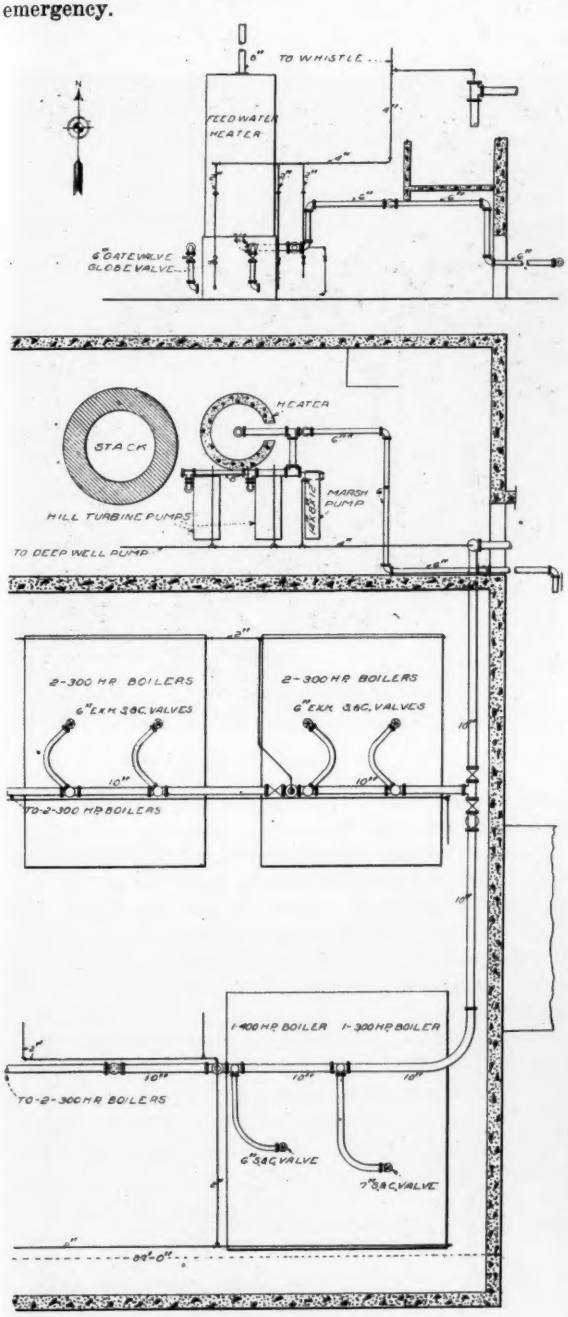


FIG. 3. PLAN OF NEW BOILER HOUSE

According to present plans, there is to be installed shortly a deep well pumping outfit to furnish the domestic supply, thereby allowing the utilization of the other sources for boiler feed and mill purposes exclusively.

Steam is ordinarily generated at a pressure of 160 lb. gage, and is delivered to a 10-in. loop header which connects with the individual units by means of 6-in. leads each carrying a stop and check valve of like size. From the header it is taken by two 10-in. main lines and distributed to the various engines, the longest run having a length of 375 ft., all of which is made up of 10-in. pipe so as to reduce the drop in pressure to a minimum.

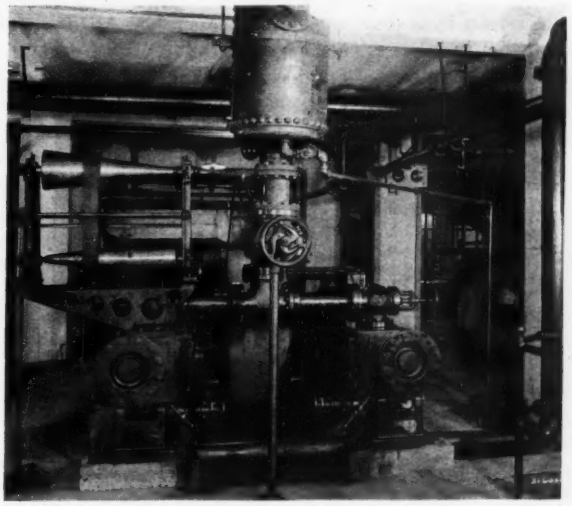


FIG. 5. CHANDLER-TAYLOR VARIABLE SPEED ENGINE IN NEW MILL

Connecting the new boiler house and the main mill basement is an 85-ft. reinforced concrete tunnel having a section of 7 by 8 ft., which serves not only as a passage way but also as a means of carrying the various water, steam, vacuum and electric service lines, two of which, each 10 in. in diameter, are for live steam, one 6-in. for exhaust steam to the feed-water heater, one 6-in. for vacuum pump discharge, one 4-in. for trap discharges, one 6-in. for house and boiler feed water supply, and one 3-in. for drinking water. These are suspended by means of inserts imbedded in the concrete and capable of carrying a load of 3000 lb. each.

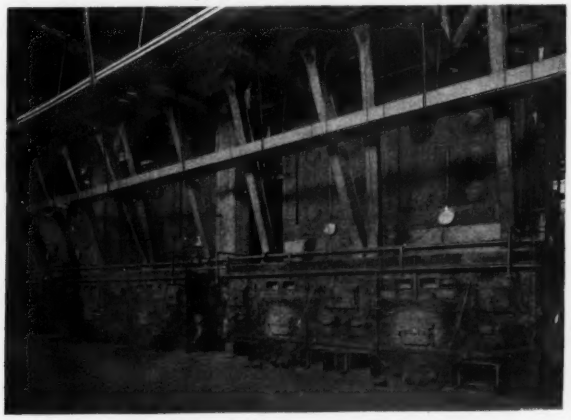


FIG. 6. THE NEW STEAM GENERATING EQUIPMENT

The Prime Movers

For operations of the electric lighting and power system, there have been installed in the original and

main engine room, located in the south end of the mill basement, a number of electric generating sets of various sizes as follows: One 22 by 28-in. Chuse Corliss engine of nonreleasing valve type, direct connected to a 250-kw. Allis-Chalmers generator; one 18 by 21-in. Chuse engine, direct connected to a 150-kw. General Electric generator; one 12 by 12-in., 45-kw. Ideal-Northern Electric set, and one 80-kw. General Electric machine belt-driven by a constant speed line shaft. All of these units deliver direct current at 220 to 240 v., and are arranged for parallel operation.

In addition to these, there are also one 12 by 12-in. twin Chandler & Taylor variable-speed engine for running the paper machine; one 12 by 36-in. constant-speed Vilter Corliss engine for the operation of the stuff pumps, screens and agitators, and one 28 by 42-in. Vilter double-eccentric engine driving the main line shafting for the beaters and jordans. In the north and new end of the mill are one 30 by 42-in. heavy duty double-eccentric Nordberg Corliss engine operating at a speed of 90 r. p. m. and driving through the medium of a 16-ft. rope wheel grooved for eighteen 1¾-in. ropes, a constant speed line shaft serving beaters and jordans; one 14 by 14-in. Chandler & Taylor twin variable-speed unit for the new paper machine, and one 14 by 17-in. Chuse set operating through a flexible coupling all of the stuff pumps, screens and agitators. The general arrangement of the prime movers is illustrated in Figs. 2 and 8.

Variable Speed Engines

Of particular interest are the two Chandler & Taylor variable-speed engines employed in connection with the paper machines. These consist of twin units with cylinders joined by a common 5-in. cross feed pipe carrying a Gardner throttling governor and with cranks which are attached to the same shaft, placed 90 deg. apart so as to obtain a more uniform turning moment and allow the engine to be started up at almost any point in the stroke. The shaft of the governor is connected to the upper one of a pair of speed changing cones by a positive but flexible gear connection. The lower cone is belted to the engine shaft by means of a heavy belt, driven over large pulleys, and the two cones are in turn connected by a special type of belt secured by a frame which may be caused to move from one end of the cones to the other by means of a long screw operated from the floor above through the medium of a link chain and sprocket wheel. Manipulation of this mechanism causes the gradual shifting of the belt along the axis of the cones, and as the governor is designed to operate at a constant speed, it is necessary for the speed of the engine to vary according to the relative location of the cone belt.

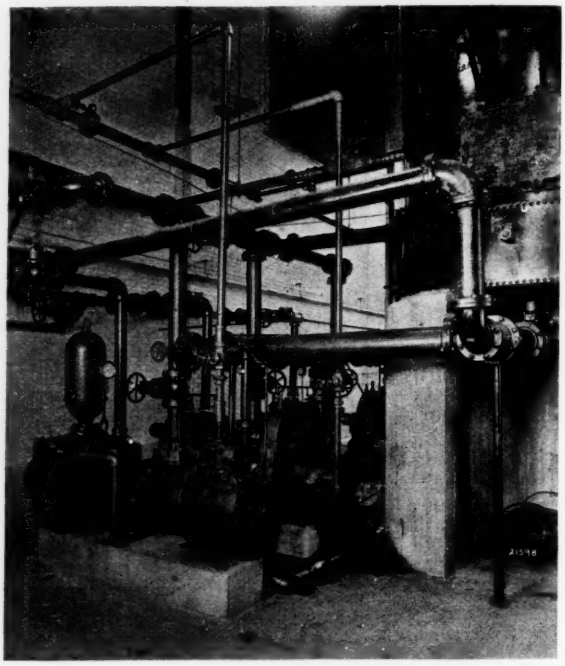


FIG. 7. VIEW IN PUMP ROOM

As a secondary and emergency speed limiting device, each of these engines is equipped with a special shaft governor attached to a separate set of pulley arms. Each of these devices remains inoperative as long as the speed of the engine is less than some predetermined value, but should the speed of the unit exceed this value,

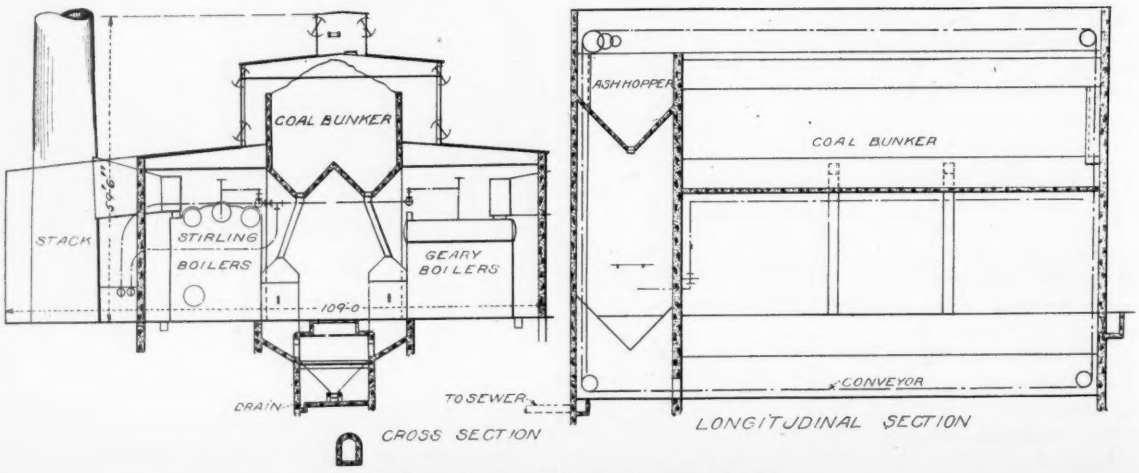


FIG. 4. ELEVATIONS OF NEW BOILER HOUSE

the valve travel is shortened and the steam cut off proportionately early.

This device is of particular advantage in the operation of paper machines, as when the engine speed reaches a maximum, the operator can readily tear off the line of paper at a point before it enters the drying rolls, and so allow the stock in the driers to clear the machine before the engine is shut down.

The unit has a minimum speed of 46 r. p. m. and a maximum speed of 276 r. p. m., and is equipped with a double lubrication system. In addition to a self-oiling forced feed system, there is installed a tank or gravity system which is in use only when the unit operates at the lower speeds.

Miscellaneous Equipment

It is quite obvious, since the daily capacity of the mill is 120 tons of paper, that large quantities of water and low-pressure steam are required. The average daily consumption of water for all purposes is 4,000,000 gal., and to provide sufficient steam all of that exhausted by the pumps and engines is employed, with at times, and especially during the heating seasons, live steam added. All of this steam, however, before being utilized for manufacturing purposes is separated from the entrained oil by being passed through a horizontally-placed, steel cylindrical separator having a diameter of 6 ft. and a length of 10 ft., and fitted with 10 and 14-in. inlets and 8, 10 and 12-in. outlets.

Hot water used in the beaters is heated in five 18 by 6-ft. closed coil heaters, and after being utilized is reclaimed for further use. In the old mill, machine and heating system returns are handled by two 8 by 12 by 12-in. Marsh vacuum pumps, while in the new mill the machine returns are cared for by a 10 by 14 by 16-in. American Steam Pump Co. pump and the heating returns by a 10 by 14 by 16-in. Burnham unit. All of these returns, together with those discharged by the various traps about the mill, are returned to the boiler feedwater heater for reuse.

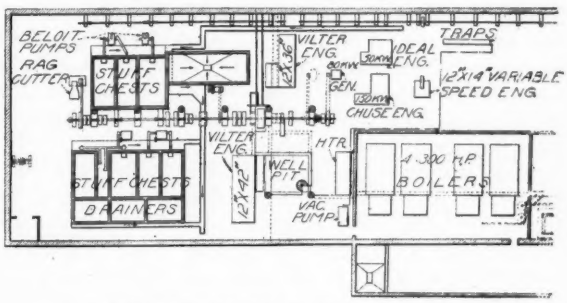


FIG. 8. PLAN OF OLD POWER PLANT

James L. Carey, paper mill architect and engineer of Chicago, was in charge of the design and installation of all of the mechanical equipment of this mill; the power department is now in charge of A. M. Petersen, Chief Engineer.

Power Plant Instruments As An Investment—VI

Automatic Feed Water Regulation. By M. A. Saller

One factor in boiler room operation that has a marked effect on the economy, capacity and safety of the plant, but which does not always receive the attention it deserves, is the matter of the proper rate and method of feeding water to the boilers, and the maintenance of the proper water level according to the conditions as to load and firing.

Too often this very important work is left to the attention of careless and indifferent firemen and water tenders who cannot or will not give the matter intelligent attention. The easiest way, and hence the method often followed, is to pump the boilers full and then allow them to run until a low level is reached, when the pumps are speeded up again. This procedure is dangerous and also inefficient because during the filling period the heater is usually overloaded at a sacrifice in the feed temperature, while exhaust steam is allowed to go to waste in the interval. The danger from oversight or neglect always present with the human element is also to be considered.

The installation of automatic feed water regulators will prove to be an excellent investment in practically every plant (excepting possibly the small plants running at a very steady load, where the feed pumps can be run at a steady rate just sufficient to supply the feed water as fast as it is being evaporated), because these automatic regulators will

(1) Eliminate the uncertainty attendant on hand regulation.

(2) Relieve the firemen or boiler room force of this care and attention.

(3) Provide a steady feed in accordance with load demands, making possible the maintenance of the highest attainable feed temperature.

(4) Maintain a steady water level which results in the production of drier steam.

(5) Make possible better firing and furnace conditions.

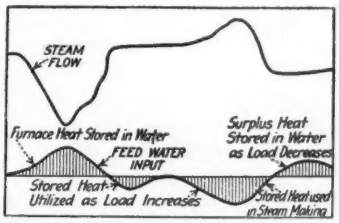

STEAM FLOW
Furnace Heat Stored in Water
FEED WATER INPUT
Surplus Heat Stored in Water as Load Decreases
Stored Heat Utilized as Load Increases
Stored Heat used in Steam Making

FIG. 1. RELATION BETWEEN STEAM OUTPUT AND FEED WATER INPUT WHEN REGULATOR IS ADJUSTED FOR STORING HEAT

(6) Reduce wear and tear (by eliminating expansion and contraction strains) in the boiler.

Where a variable load is encountered, the automatic regulation can be arranged to adjust the feeding of the water to the particular load conditions. Where fluctuating loads are encountered the regulator can be adjusted to fill the boilers with water while the load is light, and while there is plenty of excess heat available

for heating this water to the boiling point. Then when the heavy pull comes on the boiler will contain a large quantity of hot water ready to be flashed into steam, and while the load continues heavy the level will be carried low so that all the available heat is used for making steam with the minimum reduction in capacity because of heat employed in heating up the feed water. A graphic illustration of how an automatic regulator can scientifically adjust the feed to load conditions is shown in the chart, Fig. 1.

Taking up the advantages of eliminating the uncertainty of hand feeding, it is impossible to figure the benefits in dollars and cents derived from the feed water regulator on this score, though it will be appreciated that the advantage is there and is worth considerable to the safety and welfare of the plant.

The feed-water regulator will also tend toward better service in the boiler room because it relieves the firemen or boiler room attendants of the work and attention which would have to be paid to the adjustment of the feed supply. If the time formerly consumed in regulating the feed manually would be devoted to a more careful study of furnace conditions, firing and flue gas analysis, this feature alone would justify the installation of the automatic regulators.

The method of feeding water to the boilers has a marked influence on the feed water temperature, because irregular feeding will overload the heater for a short time while the pull is heavy with a consequent drop in feed temperature, while in the intervals the heater capacity and exhaust steam will be wasted. Two temperature record charts shown in Fig. 2 will demonstrate the marked difference in feed temperature occasioned by regular automatic feeding as compared with irregular spasmodic hand control. With steady feeding, a temperature of 210 deg. was maintained, an increase of 32 deg. over the average feed temperature secured with hand regulation. Since it is a well established fact that for each 10-deg. rise in the temperature of the feed water a reduction of 1 per cent in fuel consumption takes place, it will be seen that the automatic regulation in this case effected a direct saving of over 3 per cent on the fuel bill, certainly a handsome return on the investment, sufficient to pay for the cost of installation many times over in the course of a year's run. Even though the installation of the regulators will show only a reduction in fuel consumption of 1 or ½ per cent (that is, increase the temperature of the feed 5 or 10 deg.), the savings from this source alone would more than pay for the installation in a year.

Then the benefits to be derived from carrying a steady water level in the boiler must be considered, for as a result there will be less water and moisture contained in the outgoing steam. Reported tests on a 250-hp. water-tube boiler show that with the water level carried at 9 in. height, it was found that there was 1.96 per cent more moisture in the steam than when the water level was carried at 5-in. height. In other words, an increase of 4 in. in the water level caused an increase in moisture in the steam of almost 2 per cent. This excess moisture in the steam is undesirable because it reduces the steam productive capacity of the boiler, causes an accumulation of water in the steam lines, interferes with engine lubrication, etc. Where superheaters are installed this excess moisture also cuts down the degree of superheat attainable because much of the effective capacity of the superheater is used up in reevaporating the water instead of making steam.

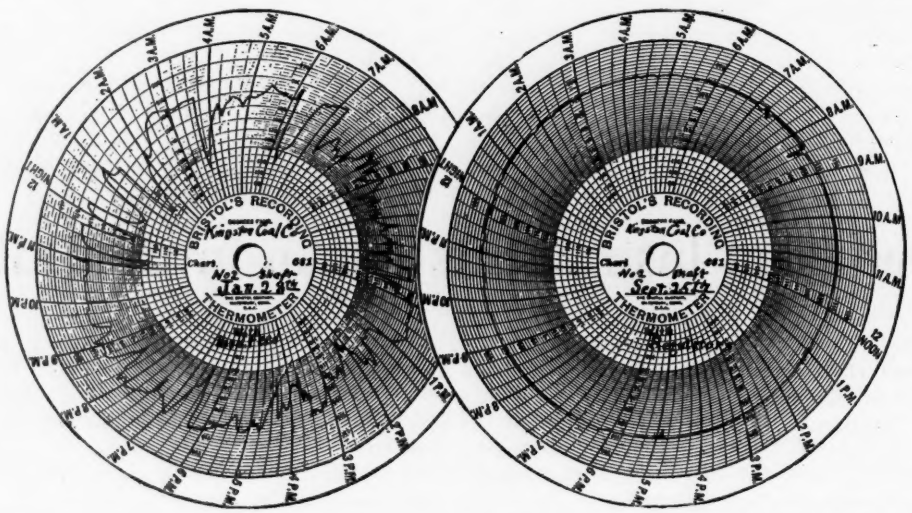


FIG. 2. FEED WATER TEMPERATURES BEFORE AND AFTER INSTALLATION OF FEED WATER REGULATOR

Steady feeding of the boiler permits uniform firing to be done and the carrying of the fire at nearly constant temperatures. The steady delivery of the water by the regulator makes it necessary for the fireman to carry his fires in a manner most favorable to economy of fuel, or otherwise the pressure will fall off.

The reduction in temperature strains in the boiler is brought about because of increased and constant feed water temperature, and the maintenance of a steady feed instead of filling the boiler with cool water at intervals.

Another incidental advantage of the steady feed afforded by the regulator is that it makes possible the use of smaller feed lines. One plant which required 6-in. feed lines while feeding irregularly by hand, was able to cut down the size of this line to 4 in. when regulators were installed. Where brass pipe is involved, this saving in cost is quite appreciable.

What to Do With the Flue Gas Analysis

METHODS OF DETERMINING FURNACE CONDITIONS AND LOSSES. BY C. A. JOERGER

IN many plants, flue gas analyses are taken to determine in a general way the behavior of the furnace. Nothing in particular is done with the results. The writer being repeatedly asked, "What shall I do with it?" gives the following as one answer:

As the result of burning coal which is practically carbon, we get carbon dioxide gas (CO_2) and carbon monoxide gas (CO), there is also present oxygen (O_2) and nitrogen (N_2). If there is any hydrogen in the coal, there will be some water (H_2O) formed; this is, however, a very small quantity and is generally neglected. This water cannot, of course, be found by the Orsat apparatus.

From a flue gas analysis by means of an Orsat apparatus we get:

a—per cent CO_2 by volume
b—per cent O_2 by volume
c—per cent CO by volume
d—per cent N_2 by volume

The N_2 is determined by difference, that is—

$$100 - (a + b + c) = d$$

The molecular weights of the various flue gases are:

$CO_2 = 44$ $\qquad$ $CO = 28$
$O_2 = 32$ $\qquad$ $N_2 = 28$

Let A, in the diagram, represent a certain volume of hydrogen and vessel B an equal volume of CO_2, at the same temperature and pressure, then B would weigh 22 times as much as A; that is, one-half the molecular weight times as much. If vessel B contained O_2 it would weigh 16 times as much as A; if it contained CO, 14 times as much, and if it contained N_2, 14 times as much. Assuming that the vessel, A, containing the hydrogen weighed 1 lb, vessel B filled with CO_2 would weigh 22 lb., filled with O_2, 16 lb., filled with CO, 14 lb., filled with N_2, 14 lb.

Filling vessel B with flue gas, we get condition B_1, Fig. 1.

The weight of CO_2 in B_1 would be $a \times 22$.
The weight of O_2 in B_1 would be $b \times 16$.
The weight of CO in B_1 would be $c \times 14$.
The weight of N_2 in B_1 would be $d \times 14$.

The total weight of flue gas would be:

$$W = 22a + 16b + 14c \times 14d$$

The per cent composition by weight of the flue gas would then be:

$$\frac{22a}{W} \times 100 = e \text{ per cent by weight of } CO_2$$

$$\frac{16b}{W} \times 100 = f \text{ per cent by weight of } O_2$$

$$\frac{14c}{W} \times 100 = g \text{ per cent by weight of CO}$$

$$\frac{14d}{W} \times 100 = h \text{ per cent by weight of } N_2$$

Taking the molecular weight of carbon as 12 and the molecular weight of oxygen as 32, we get:

(1) $C + O_2 = CO_2$
$12 + 32 = 44$
$\frac{12}{44} + \frac{32}{44} = 1$

(2) $2C + O_2 = 2CO$
$24 + 32 = 56$
$\frac{24}{56} + \frac{32}{56} = 1$

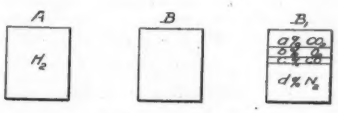
which shows that $^3/_{11}$ lb. of carbon after complete combustion will give, case 1, 1 lb. of CO_2, or $^3/_7$ lb. of carbon after incomplete combustion will give 1 lb. of CO. In W pounds of chimney gas there is 22a, as CO_2, and 14c as CO.

Then $^3/_{11} \times 22a = 6a$ is the carbon in the CO_2 in W pounds of flue gas,
and $^3/_7 \times 14c = 6c$ is the carbon in the CO in W pounds of flue gas;
hence, 6 (a + c) is the total carbon burned per W pounds of flue gas.

$\frac{a}{a+c}$ = pounds of carbon burned to CO_2 per pound of carbon burned.

$\frac{c}{a+c}$ = pounds of carbon burned to CO per pound of carbon burned.

One pound of carbon burning to CO_2 gives up 14,500 B.t.u. and 1 lb. of carbon burning to CO gives up 4400



DIAGRAMS USED IN MAKING COMPARISONS OF GAS WEIGHTS

B.t.u.; then $\frac{a}{a+c}$ (14,500 — 4400) B.t.u. is the heat lost by $\frac{a}{a+c}$ pounds of carbon burning to CO instead of CO_2 per pound of carbon burned. This is generally called the heat lost due to incomplete combustion. If K = the carbon content in 1 lb. of coal, then $K\frac{a}{a+c}$ (14,500 — 4400) B.t.u. is the heat lost per pound of coal due to incomplete combustion. With coal at $3 a ton (2000 lb.), heating value 14,000 B.t.u. per pound,

$$\frac{3}{14{,}000 \times 2000} \times K\frac{c}{a+c}(14{,}500 - 4400) = \text{dollars}$$

lost per pound of coal due to incomplete combustion.

It was shown that 6 (a + c) pounds of carbon gave W pounds of flue gas. One pound of carbon then gives $\frac{W}{6(a+c)}$ pounds of dry chimney gases;

then $W_a = e \times \frac{W}{6(a+c)}$ = weight of CO_2 per pound of carbon.

$W_b = f \times \frac{W}{6(a+c)}$ = weight of O_2 per pound of carbon.

$W_c = g \times \frac{W}{6(a+c)}$ = weight of CO per pound of carbon.

$W_d = h \times \frac{W}{6(a+c)}$ = weight of N_2 per pound of carbon.

Substituting for e, f, g, h, their values, we get:

$$W_a = \frac{a}{a+c}\ \frac{22}{6}$$

$$W_b = \frac{b}{a+c}\ \frac{16}{6}$$

$$W_c = \frac{c}{a+c}\ \frac{14}{6}$$

$$W_d = \frac{d}{a+c}\ \frac{14}{6}$$

$Z = W_a + W_b + W_c + W_d$ = weight of flue gas per pound of carbon, or KZ = weight of flue gas per pound of coal.

The heat carried off by the chimney gases per pound of coal is: $KZ\,(t_c - t_a)S_p$

t_c = temperature of the chimney gases.

t_a = temperature of the outside air.

S_p = specific heat of the chimney gases.

From $2\,C + O_2 = 2\,CO$ and $C + O_2 = CO_2$
1 vol. $= 2$ vol. 1 vol. $= 1$ vol.

we see that 1 vol. of CO_2 required 1 vol. of O_2, and 1 vol. of CO required ½ vol. of O, from which we get:

$$\frac{a + b + \frac{c}{2}}{a+c} = \frac{\text{oxygen actually supplied}}{\text{oxygen theoretically required}} = \frac{\text{air supplied}}{\text{air required}}$$

$\frac{b}{a+c} \times 100$ = per cent excess air.

An approximate furnace temperature can be gotten from the fact that

$(14{,}500 - \frac{c}{a+c}\,10{,}100)$ = actual combustion in the furnace per pound of carbon.

$(14{,}500 - \frac{c}{a+c}\,10{,}100) = Z\,(t_f - t_a)S_p$

t_f = furnace temperature.

t_a = temperature of the air.

S_p = specific heat of the products of combustion.

To illustrate by an example assume that the flue gas is composed of:

12 per cent CO_2 by volume = a
7 per cent O_2 by volume = b
1 per cent CO by volume = c
80 per cent N_2 by volume = d

The relative weights in the flue gas sample are:

CO_2	$22 \times 12 =$	264
O_2	$16 \times 7 =$	112
CO	$14 \times 1 =$	14
N_2	$14 \times 80 =$	1120
		1510 = W

The per cent composition by weight of the flue gas is:

$\frac{264}{1510} \times 100 = 17.5 = e$, the per cent by weight of CO_2

$\frac{112}{1510} \times 100 = 7.4 = f$, the per cent by weight of O_2

$\frac{14}{1510} \times 100 = .9 = g$, the per cent by weight of CO

$\frac{1120}{1510} \times 100 = 74.2 = h$, the per cent by weight of N_2

$100.0 = e + f + g + h$

$\frac{a}{a+c}\,(14{,}500 - 4400) = \frac{1}{12+1}\,(14{,}500 - 4400) =$ 777 B.t.u., lost due to incomplete combustion per pound of carbon. Assuming a coal of 0.8 carbon per pound, $777 \times 0.8 = 622$ B.t.u. lost due to incomplete combustion per pound of coal. With coal at $3 a ton, 14,000 B.t.u. heating value.

$\frac{3}{14{,}000 \times 2000} \times 622 \times 2000 =$ $0.133 lost due to incomplete combustion per ton of coal.

$\frac{12}{12+1} \times \frac{22}{6} = 3.38$ weight of CO_2 per pound of carbon $= W_a$.

$\frac{7}{12+1} \times \frac{16}{6} = 1.44$ weight of O_2 per pound of carbon $= W_b$.

$\frac{1}{12+1} \times \frac{16}{6} = 0.18$ weight of CO per pound of carbon $= W_c$

$\frac{80}{12+1} \times \frac{14}{6} = 14.36$ weight of N_2 per pound of carbon $= W_d$

$19.36 = Z$ = weight of flue gas per pound of carbon.

$19.36 \times 0.8 = 15.488$ = weight of flue gas per pound of coal.

If the temperature in the breeching is 520 deg. F., and the air temperature is 70 deg. F., the heat carried out the chimney, assuming the specific heat of the gases as 0.28, is $0.8 \times 15.49\ (520 - 70)\ 0.28 = 1562$ B.t.u. per pound of coal.

$\frac{7}{12.5} \times 100 = 56$ per cent excess air.

Assuming the air temperature as 70 deg. and the specific heat of the gases again as 0.28,

$$(14{,}500 - \frac{1}{12+1}\,10{,}100) = 19.36\,(t_f - 70)\,0.28$$

From which $t_f = 2900$ deg. F., approximate furnace temperature.

THINK WELL of yourself. Be good to yourself. You are very important to yourself. You are all the important elements of a successful man. You have within you the latent force that will lift you successward. Don't pity yourself. Don't lessen your own value in your own eyes. Have confidence in yourself. Believe in your ability to do big things. Only by having faith in yourself can you expect others to have faith in you. Treat yourself as a man of worth. Demand much of yourself. Be your own hardest taskmaster. Be determined to better the work you are doing.

Show how you can produce more at less cost of mental and physical energy. Prove that you can sell more of your product at a profit. Think big thoughts and back them up with big deeds. You can when you will you will.—T. DREIR in Wayne Winners.

Power Plant Piping Systems

TOTAL AND UNIT COST FIGURES OF REPRESENTATIVE INSTALLATIONS. BY JOHN D. MORGAN

PRESENT-DAY engineers generally recognize the piping system of a power station as one of the most difficult problems in design and construction. This is due to the ever-growing necessity for more accurate piping design on account of the more general use of high-pressures and high degrees of superheat now employed. A few years ago the use of cast-iron for high-pressure work was general; but today its use is considered bad, for in the past the steam temperature rarely exceeded 500 deg. F. and there was experienced little or no trouble in the design of expansion bends to take care of expansion. Today, however, with temperatures ranging from 700 deg. F. and upward, greater skill is required to take care of expansion.

To illustrate the importance of piping systems in a financial way, Table I has been prepared.

TABLE I. UNIT PIPING COSTS IN REPRESENTATIVE PLANTS

Station No.	Type of Station	Capacity in Kw.	Capacity in B.Hp.	No. of Main Units	No. of Boilers	Piping Cost per Main Unit Inlet Kw.	Piping Cost per Main Unit Inlet B.Hp.	Piping Cost per Cent Station Cost	Piping Cost per Main Unit Outlet	Piping Cost per Boiler Outlet
1	D.C. E	675	788	3	3	$ 9.00	$ 8.63	6.4	$ 2250	$ 2250
2	D.C. E A.C.	800	750	2	3	8.88	8.00	4.5	1425	949
3	D.C. & A.C. E	1200	900	3	4	13.20	27.25	9.96	3270	2625
4	D.C. & A.C. E	2625	3450	4	10	20.46	20.06	11.6	10500	7200
5	D.C. & A.C. E	4800	4125	6	8	15.05	15.00	6.4	9240	7200
6	D.C. & A.C. E	6450	7700	8	12	9.49	7.96	4.8	7650	4750
7	D.C. & A.C. E	3140	3472	6	6	14.97	13.06	9.96	6287	6806
8	A.C. D.C. E & T	3000	4800	4	6	8.37	8.44	5.7	6132	4088
9	A.C. D.C. E & T	4200	3800	7	8	10.04	14.75	8.9	8023	8270
10	A.C. D.C. E & T	2250	3375	5	14	8.14	9.75	7.7	6267	2250
11	A.C. D.C. E & T	6300	6750	7	12	10.05	13.38	8.3	12750	6800
12	A.C. D.C. E & T	9600	9810	15	15	6.89	10.76	4.9	6690	5040
13	A.C. D.C. E & T	17900	15080	15	27	6.69	11.98	6.4	10000	6664
14	A.C. & T	3600	1000	3	4	4.78	7.61	5.7	8565	3894
15	A.C. & T	10000	4800	2	8	4.11	6.58	4.8	20000	8134
16	A.C. & T	18000	3600	3	8	8.97	11.67	4.3	21045	7014
17	A.C. & T	75000	90120	5	20	3.56	7.98	3.3	25000	4887

E = Engine T = Turbine A.C. = Alternating-Current D.C. = Direct-Current N.C. = Non-condensing.

TABLE II. PERCENTAGE COST DISTRIBUTION OF PIPING SYSTEMS IN RELATION TO TOTAL PIPING COSTS

Station	Kw. Capacity	B.Hp. Capacity	Type of Station	S. P. Lines	Exhaust Steam	Atmos. Exhaust	Feed Water	L. P. Water	Blow-Off	Drips & Drains	H. P. Oil	L. P. Oil
A	600	892	E	38.9	1.8	36.9	9.2	24.0	----	1.1	----	0.9
B	675	788	E	32.8	30.0	2.4	7.1	20.2	2.7	0.6	----	2.2
C	750	900	E N.C.	43.0	38.2	Included in Ex.	6.9	2.4	0.4	2.2	----	2.2
D	800	750	E N.C.	40.6	2.7	2.2	9.2	15.0	2.4	2.7	----	2.4
E	1200	620	E	32.6	4.1	16.6	9.3	25.0	1.2	2.7	----	2.2
F	2625	3450	E	16.2	15.1	2.2	2.22	26.1	1.2	1.1	----	2.4
G	4800	4125	E	20.6	22.4	13.2	10.2	20.2	2.2	2.7	----	----
H	6450	7700	E	24.1	16.1	2.2	2.4	19.0	1.0	2.0	1.2	1.2
I	3140	3472	E & T	22.7	10.2	1.2	4.2	22.4	2.2	1.1	0.27	0.72
J	3000	4800	E & T	22.2	2.7	7.2	10.1	24.2	1.2	2.2	2.2	2.4
K	4200	3800	E & T	22.2	2.2	12.2	7.2	22.2	2.2	2.2	----	2.2
L	2250	3375	E & T	24.6	11.2	2.2	14.2	12.2	2.1	2.2	----	1.12
M	6300	6750	E & T	21.2	17.2	12.2	17.2	22.2	2.2	2.2	----	2.2
N	9600	9810	E & T	22.7	12.2	10.2	2.7	22.2	1.1	1.24	----	----
O	17900	15080	E & T	22.2	12.7	12.2	12.2	22.2	2.2	2.2	----	2.2
P	1200	1000	T	22.2	12.1	12.1	2.2	22.2	2.7	2.4	----	----
Q	10000	4800	T	22.1	2.2	2.2	12.2	22.2	2.2	2.2	----	4.12
R	18000	3600	T	22.7	22.2	Included in Ex.	7.2	12.2	2.2	2.2	2.2	2.2
S	75000	90120	T	24.2	7.2	7.2	17.2	17.2	2.2	2.2	2.2	2.1

E = Engine T = Turbine N.C. = Non-Condensing

TABLE III. DISTRIBUTION OF PIPING COSTS IN RELATION TO TOTAL PIPING COSTS

Station #	Type of Station	KW Capacity	B.H.P. Capacity	Pipe Cost	Offsets & Bends Cost	Fittings & Flanges Cost	Valve Cost	Hanger Cost	Total Material Cost	Labor Cost	Total Labor & Material Cost	Adv. Cor. Cost Labor & Material
1	E	600	892	18.2%	1.00%	49.2%	9.1 %	0.7 %	78.2%	17.0%	93.2%	6.8%
2	E	675	788	33.6	---	29.1	13.9	1.6	77.2	16.0	97.2	12.8
3	E	750	900	19.2	---	26.2	12.7	10.0	68.2	17.2	100.	---
4	E	800	750	28.1	---	24.2	13.2	2.1	80.6	17.2	98.1	1.2
5	E	1200	620	21.4	0.2	32.4	9.2	1.2	76.0	17.2	92.2	7.2
6	E	2625	3450	42.1	1.1	22.2	6.2	2.4	76.2	17.2	93.4	6.2
7	E	4800	4125	23.2	0.7	32.4	7.4	2.2	77.4	18.2	95.7	4.2
8	E	6450	7700	20.2	1.1	22.2	13.1	2.27	69.2	16.2	98.4	11.6
9	E & T	3140	3472	26.2	0.7	32.4	14.2	2.1	78.2	20.2	94.2	5.2
10	E & T	3000	4800	22.2	0.7	24.1	12.2	2.7	72.2	19.2	92.2	7.2
11	E & T	4200	3800	25.2	0.66	22.2	9.2	2.2	72.2	16.2	92.1	7.2
12	E & T	2250	3371	21.2	1.7	22.7	14.2	2.22	64.2	17.2	92.1	14.2
13	E & T	6300	6750	22.2	2.2	27.4	22.2	1.2	72.2	16.2	92.2	7.2
14	E & T	9600	9810	21.2	2.2	22.1	20.7	2.22	66.2	16.4	97.4	12.4
15	E & T	17900	15080	22.4	2.22	27.2	22.22	4.22	72.2	16.2	92.2	10.2
16	T	1200	1000	21.2	2.2	22.2	16.22	1.2	72.2	16.2	92.1	2.2
17	T	10000	4800	22.2	1.2	22.2	22.7	2.2	72.2	16.2	92.2	12.2
18	T	18000	3600	17.2	1.2	22.2	22.7	2.2	72.7	16.1	92.2	12.2
19	T	75000	90120	22.2	1.2	22.7	22.2	2.1	72.2	20.1	92.2	2.2

E = Engines T = Turbines

TABLE IV. DETAILED PIPING COSTS OF A 4000-KW. PLANT HAVING 6 GENERATING UNITS AND 8 BOILERS

System	Pipe Cost	Flanges and Fittings Cost	Offsets and Bends Cost	Valves Cost	Hanger Cost	Total Material Cost	(1) Per Cent	Labor Cost	(2) Per Cent	Total Labor & Material Cost	(3) Per Cent	Adv. Cor. Cost	(4) Per Cent	Total
Steam	$ 322	$ 994	----	$ 220	$ 28	$ 1564	8.7	$ 170	11.4	$1782	9.1	$ 21	1.2	
Drips & Drains	122	13	----	20	----	154	0.8	470	310.0	624	3.21	212	30.0	
H. P. Steam	1551	4120	$ 122	906	271	6820	34.9	1260	18.0	8080	30.9	2552	30.7	
Ex. Steam	121	902	----	58	24	1104	6.4	620	30.0	1820	9.3	372	30.4	
Feed Water	211	1401	----	476	42	2284	0.1	419	12.7	2853	7.2	272	30.9	
Atmos. Ex.	2291	3220	12	297	102	6427	33.6	214	4.9	6741	19.2	2	----	
Oil Piping	120	----	----	62	----	212	0.2	120	69.2	452	1.17	----	----	
Comp. Air	12	----	----	----	----	12	----	64	412.0	67	0.12	----	----	
Gauge Piping	21	----	----	25	----	72	0.02	62	21.2	122	0.4	----	----	
L. P. Water	4727	2220	42	1227	124	8620	21.2	1264	12.2	10284	22.2	241	1.27	
Excavation	----	----	----	----	----	----	----	----	----	27	----	27	0.12	----
General Labor Expense	----	----	----	----	----	----	----	1264	----	1264	6.2	----	----	
Total	9421	12222	172	2202	742	27426	100.0	7020	25.2	34460.	160.0	2222	8.0	27421
% of Grand Total	22.2	32.2	0.42	5.2	2.2	72.2	------	12.2	----	22.1	----	7.2	----	100%
Cost per Kw.	$2.42	$3.27	0.044	0.22	0.127	6.222	------	1.757	----	8.212	----	0.722	----	2.222
Cost per B.Hp.	$2.22	$1.22	0.022	1.22	0.222	2.22	------	0.222	----	12.22	----	1.222	----	12.12

(1) = % of Total Material Cost (3) = % of Total Labor & Material Cost
(2) = Labor + Material Cost (4) = Adv. Cor. Cost + Total Labor & Mat. Cost

Note: — In several places no account was made of the small fittings used. These were charged to other accounts.

TABLE V. MATERIAL SIZES AND SAFE WORKING LOADS FOR VARIOUS SIZES OF PIPE HANGERS

Pipe Size, In.	Pipe Band		Clamp		Dia. of Rod, In.	Bolts		Safe Load Lb.	Length of Band In.
	Thick, In.	Wide, In.	Thick, In.	Wide, In.		Band	Clamp		
2	1/4	1-1/4	3/8	1-1/4	1/2	1/2 by 2	1/2 by 2-1/4	1180	6
2-1/2	1/4	1-1/4	3/8	1-1/4	1/2	1/2 by 2	1/2 by 2-1/4	1180	7
3	1/4	1-1/2	3/8	1-1/2	1/2	1/2 by 2	1/2 by 2-1/4	1180	8
3-1/2	1/4	1-1/2	3/8	1-1/2	1/2	1/2 by 2	1/2 by 2-1/4	1180	9
4	1/4	1-1/2	3/8	1-1/2	5/8	1/2 by 2	5/8 by 2-1/4	1870	10-1/2
4-1/2	1/4	1-1/2	3/8	1-1/2	5/8	1/2 by 2	5/8 by 2-1/4	1870	11
5	1/4	2	3/8	1-1/2	5/8	1/2 by 2	5/8 by 2-1/4	1870	12
6	1/4	2	3/8	2	5/8	5/8 by 2-1/4	3/4 by 2-1/4	1870	14
7	5/8	2	1/2	2	3/4	5/8 by 2-1/4	3/4 by 2	2820	16
8	5/8	2	1/2	2	3/4	3/4 by 2-3/4	7/8 by 2-1/4	2820	18
9	5/8	2	1/2	2-1/4	7/8	3/4 by 2-3/4	7/8 by 2-1/4	3940	20
10	1/2	2	1/2	2-1/2	7/8	3/4 by 3	7/8 by 2-1/4	3940	22
12	1/2	2-1/4	1/2	2-1/2	1	7/8 by 2-1/4	1 by 2-1/2	5180	25
14	1/2	2-1/4	1/2	2-1/2	1-1/8	1 by 2-1/2	1-1/8 by 2-3/4	6810	27
16	1/2	3	5/8	3	1-1/8	1-1/8 by 2-3/4	1-1/4 by 4	6810	30
18	5/8	3	5/8	3	1-1/4	1-1/8 by 4	1-1/4 by 4	8410	32
20	5/8	3	3/4	3	1-1/4	1-1/4 by 4	1-1/4 by 4-1/2	8410	37
22	3/4	3	3/4	3	1-1/4	1-1/4 by 4-1/2	1-1/4 by 4-1/2	8410	39
24	3/4	3	3/4	3	1-1/4	1-1/4 by 4-1/2	1-1/4 by 4-1/2	8410	42

TABLE VI. COST OF CAST-IRON BELL AND SPIGOT CLASS B PIPE

Size Inches	Price per ton plus $1 per ton for cartage	Weight per Foot	Feet per Ton	Pipe Cost per Foot	Excavation Cost	Laying and Calking	Lead at 6½ cents per Pound	Yarn at 6½ cents per Pound	Total	Tools, Coal, Foreman, etc.	Final Cost in Place
3	$36.75	18.8	123.46	.2978	.17	.014	.0819	.0109	.5143	.0643	.58
4	31.75	21.7	92.17	.3446	.2126	.02	.0402	.001	.6963	.0772	.70
6	30.75	35.5	60.0	.4783	.295	.032	.0861	.0015	.7939	.0992	.80
8	29.75	47.5	42.1	.6839	.375	.043	.0721	.002	1.076	.1344	1.21
10	27.75	63.8	31.36	.8851	.50	.060	.0814	.0024	1.3239	.1654	1.49
12	"	82.1	24.36	1.1391	.5575	.075	.1034	.0028	1.8578	.2073	1.97
14	"	108.5	19.0	1.4231	.3078	.098	.1194	.0057	1.9007	.2498	2.35
16	"	126.0	16.0	1.7344	.415	.115	.165	.0043	2.4337	.3042	2.73
18	"	150.0	13.3	2.0865	.4375	.1375	.1852	.0048	2.8488	.3561	3.21
20	"	176.0	11.43	2.4279	.5226	.15	.2019	.0057	3.3179	.4147	3.73
24	26.75	253.3	8.87	3.1215	63	.21	.2404	.006	4.2097	.5263	4.74
30	"	333.3	6.0	4.453	.824	.300	.297	.0096	5.9236	7.436	6.74
36	"	464.3	4.43	6.0364	1.125	.415	352	.0138	7.9442	.993	8.94
42	"	591.7	3.38	7.9142	1.55	.542	.3905	.0165	10.2133	1.2767	11.49
48	"	750.0	2.66	10.0664	1.86	.686	.4675	.0201	12.79	1.5988	14.38

Few engineers in laying out piping systems know the variety of lines needed. To illustrate this fact, one need only pick up a piping drawing and go into the station and note where the construction engineers have had to

depart from the drawing on account of interferences. To give a general idea of the principal pipe lines, the following table has been made up.

Steam Lines

(1) Main high-pressure superheated steam line;
(2) Duplicate high-pressure superheated steam line;
(3) Auxiliary high-pressure superheated steam line;
(4) Main high-pressure saturated steam line;
(5) Duplicate high-pressure saturated steam line;
(6) Auxiliary high-pressure saturated steam line;
(7) Main exhaust steam line;

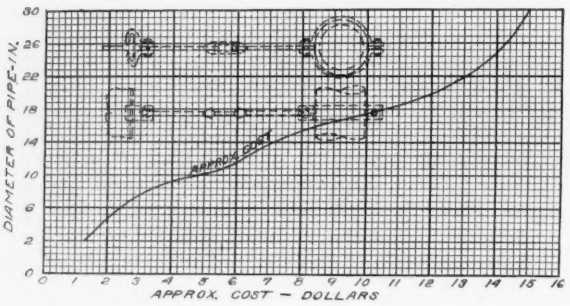


FIG. 1. APPROXIMATE COST OF STANDARD PIPE HANGERS

(8) Auxiliary exhaust steam line;
(9) Atmospheric exhaust steam line;
(10) Atmospheric exhaust from feed water heater;
(11) Atmospheric exhaust from blowoff tank;
(12) Line to damper regulator, whistle, etc.

Water Lines

(13) Discharge and suction lines of boiler feed pumps;
(14) Discharge and suction lines of condenser circulating pumps;
(15) Discharge and suction lines of vacuum pumps;

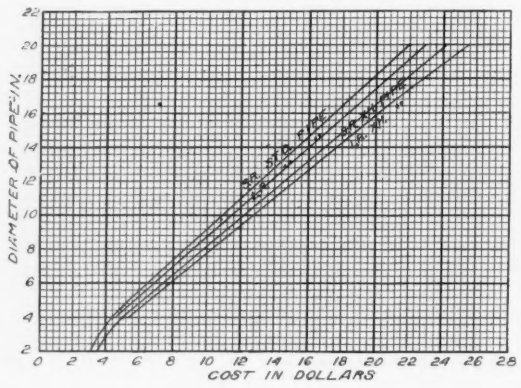


FIG. 3. LABOR COSTS OF MAKING OFFSET BENDS (STEEL PIPE)

(16) Discharge and suction lines of fire pumps;
(17) Discharge and suction lines of house service pumps;
(18) Discharge and suction lines of hot-well pumps;
(19) Discharge and suction lines of water cooling pump;
(20) Discharge and suction lines of sump pump and misc. pumps;
(21) Discharge of condensers;
(22) Lines from surge tanks to feed-water heaters;
(23) Overflow lines from feed-water heaters;
(24) Lines to boiler balanced draft system;
(25) Lines to and from venturi and V-notch meters;
(26) Lines to and from superheater, flooding lines;
(27) Lines to and from all turbine glands;
(28) Lines to and from air cylinder on air compressors and dry vacuum pumps;

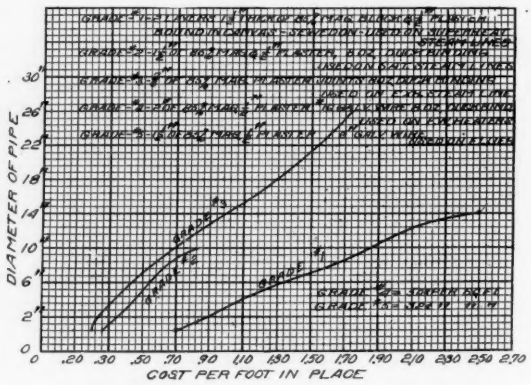


FIG. 2. COST OF PIPE COVERING AS OF JAN. 1, 1916

(29) Condenser priming lines;
(30) Centrifugal pump priming lines;
(31) Condenser priming lines;
(32) Ash sprinkling lines;
(33) Fire lines;
(34) Overflow from hot-wells and tanks;
(35) Discharge from steam traps;
(36) Lines to and from water cooled transformer;
(37) Lines to and from boiler compound mixing tanks;
(38) Lines to and from washing machines, etc.

Drips and Drains

(39) Lines from turbines and engines;
(40) Lines from boilers and superheaters;

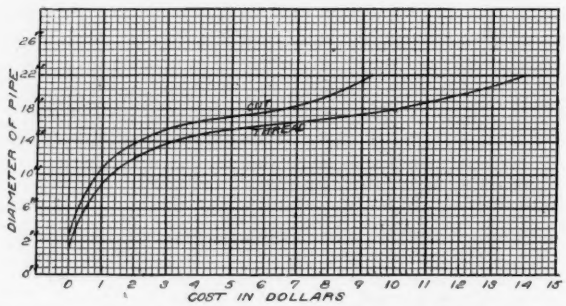


FIG. 4. COST OF CUTTING AND THREADING PIPE IN FIELD

(41) Lines from auxiliaries;
(42) Lines from all pumps;
(43) Lines from all steam and water mains;
(44) Lines from feed water heaters and separators.

Blowoff Piping

(45) Lines from boilers to blowoff tank;
(46) Lines from feed water heaters and safety valves.

Air Piping

(47) Lines from condensers to air pumps.

Gage Piping

(48) Lines to all gages, mercury columns, recorders, etc.

Gas Piping

(49) Lines for light and heat.

Small Piping Systems

(50) Compressed air system;
(51) Step bearing oil system;
(52) Hydraulic gear oil system;

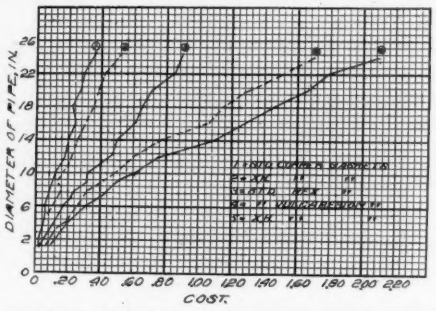


FIG. 5. COMPARATIVE COST OF GASKETS AS OF JAN. 1, 1916

(53) Turbine oiling system;
(54) Engine oiling system;
(55) Fuel oil system;
(56) Boiler feed pump regulator piping;
(57) Refrigeration system.

For cost analysis these various piping systems and lines can be condensed to the following classifications:

(1) High-pressure steam;
(2) Exhaust steam;
(3) Atmospheric exhaust;

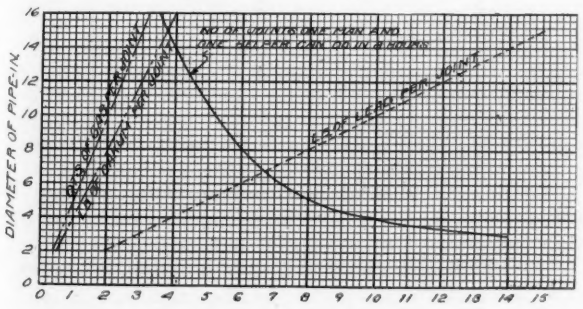


FIG. 7. LEAD AND OAKUM PIPE JOINT DATA

(4) Feed water piping;
(5) Low-pressure water piping;
(6) Blowoff piping;
(7) Drips and drains;
(8) High-pressure oiling system;
(9) Low-pressure oiling system.

To illustrate the relative costs of these various systems in relation to the total piping cost, Table II was prepared from which will be noticed a wide variation in the low-pressure water column. This is due mainly to the fact that in some stations concrete intake canals were used instead of piping; hence, where such is the case, the low-pressure water lines cost does not include the cost of the concrete intake canal.

In any particular piping job the costs of such a system are generally subdivided as follows:

Pipe costs; offsets and bends; fittings and flanges; valves; hangers; erection labor; asbestos covering.

For the cost of the above items in relation to the total piping cost see Table III in which the valve cost does

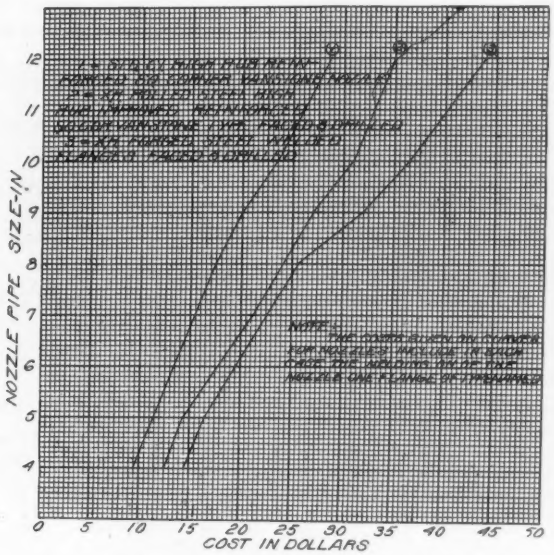


FIG. 6. APPROXIMATE COST OF PIPE NOZZLES

not include the valves that go with the main and auxiliary units as for instance the valves between the engine cylinders, throttle valves, atmospheric relief valves, non-return and blowoff valves, etc.

To show the actual figures obtained in practice Table IV was prepared. This shows the detailed piping cost of a 4000-kw. plant having 6 main units and 8 boilers with a total capacity of 2860 hp.

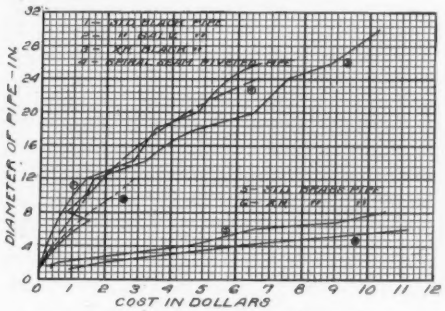


FIG. 8. PIPE COSTS, PRICE PER FOOT

Note. In several places no account was made of the small fittings used; these were changed in other accounts.

Pipe Hangers

The designing of suitable hangers for piping in general is a matter of great weight and skill. The locations of hangers should be worked out in a careful manner. But for general all around work a standard hanger can be made up, such as for example the hanger

shown on the curve, Fig. 1 giving the approximate cost of pipe hangers. Table V shows the material sizes best suited and safe working loads for various sizes of pipe hangers.

In a great many cases a considerable amount of bell and spigot class b pipe will be used for water and to place such a line properly requires men who are experts in calking. A poor joint is always a source of annoyance and especially is this true of bell and spigot pipe, for this is generally laid under ground. In considering the cost of this kind of work, due allowance

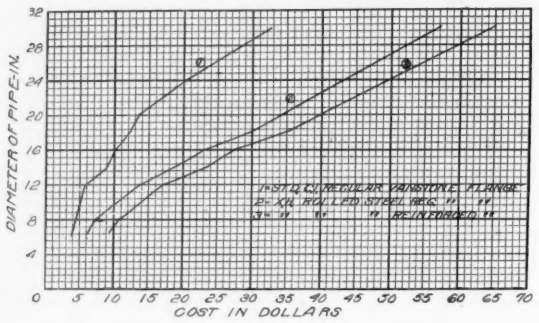


FIG. 9. APPROXIMATE COST OF VAN STONE JOINTS

must be made for all items entering into it as, for instance, the cost of pipe per ton, yarn per joint, lead per joint, cartage, laying, calking and cutting, trenching and refilling, shoring, etc. To illustrate the approximate cost of this work Table VI has been prepared. This table takes into account all the various items mentioned in a general way and for normal times such as Jan. 1, 1916, it will be found to be very accurate.

Engineers in general will find that if close attention is paid to the piping layout many operating troubles

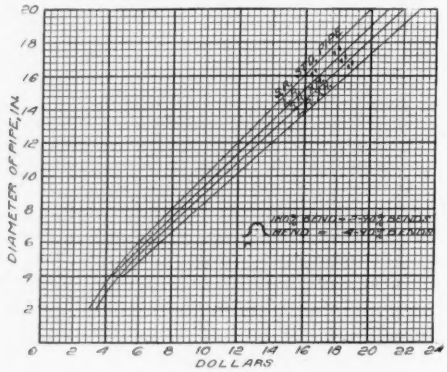


FIG. 10. LABOR COSTS OF MAKING 90-DEG. BENDS (STEEL PIPE)

will be avoided and in every case they should remember the best is none too good. Given herewith are curves which show the main costs of various items that enter into piping costs. These prices are not of today, but rather are the prices of normal times, say for Jan. 1, 1916.

WHETHER one hundred men or one thousand men know you well and favorably makes a wonderful difference to you in business, socially and in successfully four-squaring your life.

Where's the Engineer?

BY JOHN PIERCE

(With Apologies to Frank S. Perry)

IN THE land of German Kultur—wrought from lust of land and war,
Where the Prussian rules with iron and the nation's god is Thor;
On the cannon pierced Gibraltar, with its guarding rock front sheer,
You will find—now do not doubt it—find the busy engineer.

You will find him on the sand lands, in the wastes of Timbuctoo,
Where the sand flea fights the lizard, (for they've nothing else to do).
On Switzerland's white mountains, in the high bright sunlight clear,
Just cast your eye about you. You'll spot the engineer.

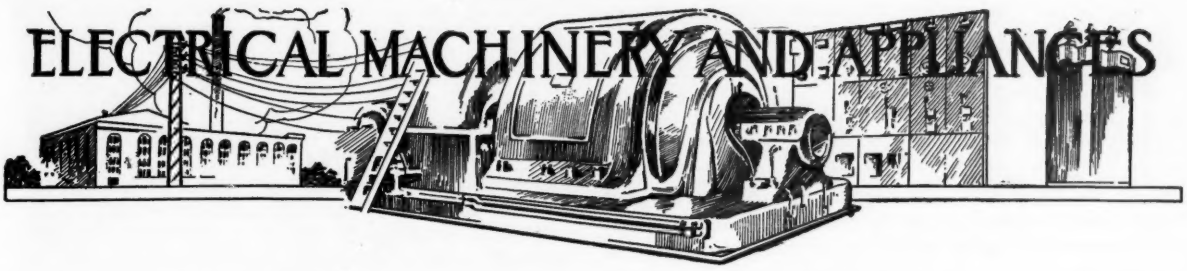
Or in that land so sunny, of strong undaunted soul,
Where women work, men fight and dare, to keep their country whole,
Where life was love and laughter, with never a flowing tear,
You'll find among the Frenchmen the steadfast engineer.

Down in the rocky bleakness of Patagonia's wild,
Where the eagle robs the buzzard to feed his starving child,
Or to the ground low swooping, bears off the youngling dear—
Lord knows what he is there for—but there's the engineer.

In Manana land where Huerta tried ruling, but to fail,
Where Pershing chased fox Villa to put the scamp in jail,
'Mongst the mountains and the cities where Carranza's troubles clear,
You'll find that faithful servant, the watchful engineer.

Go where the ruthless reaper has severed life's bonds sweet,
If St. Peter lets you pass there, and you walk the golden street,
You've passed the land of shadows—you've reached reward so dear,
Just turn about—behold him, the smiling engineer.

Or—should Peter, stern, reject you, and speed you down below,
Where 'tis natural to expect you, though you may not like the blow,
Where Hell's fires are hotly burning—you'll be greeted, have no fears,
By a cheerful whoop—a red-hot scoop—and a bunch of engineers.



Speed Regulation and Control of D. C. Motors

A Discussion of the Characteristics of the Various Types of Machines. By Terrell Croft

A SPEED-TORQUE classification of loads that may be driven by direct-current motors should be considered. Motors of the different types described herein have different operating characteristics which determine their adaptabilities for different classes of work. The different kinds of loads which motors may be called upon to drive may be divided into three classifications, thus:—

Constant torque at variable speed, variable torque at constant speed and variable torque at variable speed.

Loads of constant torque at variable speed are those where the load-torque is always practically constant, but where the speed at which the load is raised or driven must be varied. Cranes, hoists and elevators offer loads of this character. Series motors have characteristics which render them adaptable for driving such loads.

Loads of variable torque at constant speed are those imposed by machine tools such as lathes, planers and saws, by line shafts and by all other machinery the speeds of which must be maintained practically constant, but the loads of which may be almost zero at one instant and maximum a few instants later—or may vary more or less at different times. Shunt and compound motors are adapted for such services.

Loads of variable torque at variable speed are those such as imposed by railway traction loads. For example, in starting a car, the torque required is a maximum while the speed is a minimum; but after the car has been started, the torque required decreases while the speed increases. Series motors have characteristics which adapt them for such service.

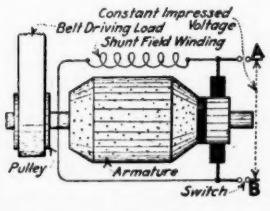


FIG. 1. THE ELEMENTS OF A SHUNT MOTOR

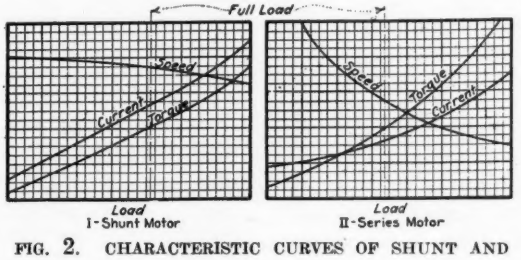


FIG. 2. CHARACTERISTIC CURVES OF SHUNT AND SERIES MOTORS

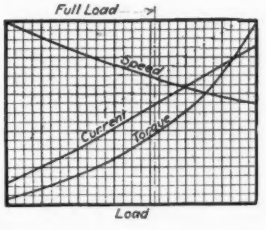


FIG. 3. CHARACTERISTIC CURVES OF A COMPOUND WOUND MOTOR

Speed Characteristics

THE THREE GENERAL TYPES of motors classified in accordance with the method whereby the field windings are connected, are the same as the three general types of generators, viz.—(1) shunt, (2) series, and (3) compound. Each of these is discussed in the following paragraphs. Just as the generators of the different types have different characteristics, the motors of the different types also have different characteristics. When one speaks of the characteristics of a generator, it is ordinarily its voltage characteristic which is referred to, the speed of the machine remaining constant and the load varying. On the other hand, when speaking of the characteristic of a motor, it is the speed characteristic which is referred to, the impressed voltage remaining constant and the load varying. This follows because motors practically always operate from constant-voltage circuits while generators are practically always driven by constant-speed prime movers.

As will be shown, the speed characteristics of motors of the different types (shunt, series or compound) are similar to the voltage characteristics of generators of the corresponding types. For example: a generator of a type which will maintain a practically constant voltage while the loads which it is serving change, its speed remaining constant, will, when operated as a motor, maintain a practically constant speed when its load varies, the impressed voltage remaining constant.

"Speed regulation" and "speed control" are two terms that have certain specific meanings just as do the terms "voltage regulation" and "voltage control." Speed regulation refers to changes in speed caused by the interactions inherent to and within the motor itself as the load driven by it decreases or increases. Speed control refers to changes in speed effected by hand or by the automatic manipulation of some device, usually external to the motor itself, whereby the speed of the motor is changed.

The speed regulation of a motor may be expressed as a percentage, calculated thus:—

(1) Speed Regulation=

$$\frac{\text{No-load r. p. m.} - \text{Full-load r. p. m.}}{\text{Full-load r. p. m.}}$$

Or, formulating this as a rule, we may say the speed regulation of a motor is the percentage of the full-load speed that the speed of the motor decreases from no-load to full-load.

If the speed of a motor at no load is 1800 r. p. m. and its speed at full load is 1720 r. p. m., its speed regulation is equal to the difference between (1800 and 1720) ÷ 1720, which in turn is equal to 80 ÷ 1720, or 0.047, or 4.7 per cent speed regulation.

Then again if a motor has a speed regulation of 5 per cent and its no-load speed is 1000 r. p. m. its full-load speed will be equal to 1000 ÷ 1.05 or 954 r. p. m.

Or, if a motor has a speed regulation of 4 per cent and its full load speed is 800 r. p. m., its no-load speed will be equal to 800 plus the product, of 800 times 0.04, or 832 r. p. m.

The shunt motor, Fig. 1, will be considered first because its characteristics adapt it to so many applications that it is used more frequently than are direct-current motors of any of the other types. Its most important characteristic is that, with a constant (unvarying) impressed voltage, it will maintain practically constant speed under wide variations in load. Why this is true will be explained. Commercial shunt motors are practically identical in construction with shunt generators. Any shunt motor may be operated as a generator and vice versa. The characteristic curves of a shunt motor and of a series motor are shown side by side in Fig. 2 for comparison. In Fig. 3 the characteristic curves of a compound-wound motor are given.

The explanation of the speed regulation of the shunt motor, that is, why a shunt motor always maintains a practically constant speed even when its load varies widely, is this:—

Consider the diagrammatic illustration of a shunt motor shown in Fig. 1, which indicates only the essentials. Assume that the switch is closed, impressing a constant voltage across A-B. This will excite the field winding and its excitation current and field strength will remain constant as long as the impressed electromotive force remains constant. Furthermore, current will be forced through the armature. (In practice, resistance is inserted in the armature circuit when a motor is started; but this feature will, for the present, be disregarded). Due to the interaction of the shunt-winding field and the field developed by the current in the armature conductors, the armature will start to rotate and it will "speed up" until it attains some certain speed such that the counter electromotive force, induced in it plus the I R A drop in it just equal the impressed voltage. Obviously, the speed thus attained will be determined by the design—field, strength, number of armature conductors, etc.—of the motor in question.

Practically, it may be assumed that the counter electromotive force when the motor is operating at no load is equal to the impressed electromotive force because, at no load, the I R A drop is very small. Hence, at no load, practically no current is forced through the motor by the voltage of the line. The power then developed by the motor, assuming for simplicity that it is 100 per cent efficient will be, in watts, equal to the product of the impressed voltage and the current. Since the current is, at no load, very small, the power developed at no load will be correspondingly small and all that is then produced will be lost in overcoming the internal friction and windage of the machine and electrical losses and none will be available at the motor shaft for carrying load.

Now assume that the load which the motor is carrying is increased considerably. The motor will slow down—not much, only a very little. The armature conductors will cut a less number of magnetic lines of force per second and hence, will induce a smaller counter electromotive force. This will permit the forcing of the greater current, necessary to pull the load, from the line through the armature; however, as will be shown, a very slight decrease in armature speed (counter electromotive force) allows a considerably greater current to flow through the armature, so that the motor will maintain practically the same speed when pulling this considerable load as it did when it was pulling no load at all. Again, the power developed by the motor will be equal to the product of the number of volts and the number of amperes; but now the current is considerable and the power developed will be correspondingly great.

If the load on a shunt motor decreases, the armature will "speed up" a trifle, thus inducing a greater counter electromotive force and affecting a material decrease in the current being forced through the motor. Furthermore, the power in watts developed by the motor will also equal the number of volts times the number of amperes, but since the current is now smaller than before the power developed will be proportionately less.

Thus it is apparent that a shunt motor will maintain practically constant speed as the load it is pulling varies and that it automatically regulates the intensity of the current forced through it at any instant in proportion to the load it is pulling at that instant. Numerical examples further illustrating this condition are given below.

The automatic speed regulation of the shunt motor may be explained numerically thus:—The force tending to thrust a current-carrying conductor from a magnetic field is:—

(2) $\text{Flb.} = 0.000{,}000{,}088 \times I_A \times L \times B$ (pounds).

In a shunt motor operating on a constant-voltage circuit the flux density B remains practically constant because the current through the shunt-field winding is always about the same. Furthermore, length L, of the armature conductors in the field, always remains constant in a given armature. Obviously, if the torque of the motor is to vary at different loads, the armature current I_A, must vary.

It has been shown that the current through an armature is:— $I_A = (E - E_B) \div R_A$. Hence, the armature current I_A can be increased only by increasing E, decreasing E_B or decreasing R_A; but on a constant voltage circuit, E is constant and in any given motor

R_A is constant. It follows that if the armature current, hence torque, of any given operating motor is to be increased to drive a greater load, its counter electromotive force E_B must decrease. The counter electromotive force of a motor will be decreased when its armature rotates at a lower speed—this counter electromotive force varies directly as the speed of rotation.

When then, the load on a motor is increased its speed and hence its counter electromotive force decrease somewhat and a greater current is forced through the armature from the line. Thereby the torque of the motor is materially increased and it pulls its load at a very slightly decreased speed. Consider the following examples.

A shunt motor is connected across a constant-voltage 220-v. main. Its armature resistance is 0.5 ohm. It is operating at such a speed that its counter electromotive force is 215 v. Then the armature current will be: $1 = (E - E_B) \div R_A = (220 - 215) \div 0.5 = 5 \div 0.5 =$ 10 amp. Now assume that an additional load is thrown on the motor which decreases its speed 1 per cent, then the counter electromotive force will be decreased 1 per cent and will be:—$0.99 \times 215 = 213$. Under these conditions the armature current will be:—$(220 - 213) \div 0.5 = 7 \div 0.5 = 14$ amp. Thus, with a decrease of only 1 per cent in speed, the armature current has been increased by:—$(14 - 10) \div 10 = 4 \div 10 = 0.4$ or 40 per cent.

The power being developed by the armature when the armature current was 10 amp.; was:—10 by 215 or 2150 w. or 2.88 hp. But with the 14 amp. armature current the power is:—14 by 213 or 2982 or 3.99 hp. Obviously, in this case the power has been increased by $(3.99 - 2.88) \div 2.88 = 1.11 \div 2.88 = 0.38$ or 38 per cent. (The increase in power is not quite proportional to the increase in current shown in the above paragraph because the $I^2 R_A$ watts power loss in the armature increases as the square of the armature current). Thus, with a decrease in speed of only 1 per cent the power output of the armature has been increased 38 per cent.

Foundations for Generators and Motors

ROCK FILLING in concrete foundations can be used effectively if rocks or boulders are readily obtainable. Ordinarily, machinery foundations, where made of concrete, are homogeneous; that is, they comprise a uniform mixture of cement, sand and crushed stone or gravel. Where rocks are plentiful, however, the body of the foundation can be packed with rocks as shown in Fig. 1, effecting a saving in time and material. Frequently boulders are plentiful in the vicinity of the location where a foundation is being built and they cost only the price of the labor required to get them to the foundation site. Often old masonry foundations are replaced by new ones of concrete. In such cases, the stone taken from the old foundation can be used as filler in the new one. With this construction each boulder should be wholly surrounded by concrete, and there appears to be no reason why a foundation so made is not as good as one of solid concrete.

In constructing a foundation by this method, a layer of concrete, possibly 8 in. thick, may be dumped into the hole and then some of the material is packed around the anchor plates or the casings keeping the bolts in place. Then rocks are bedded in this concrete layer. A sufficient number of them should be used to practically cover its entire surface. A 2½ or 3-in. space should be allowed between adjacent rocks to permit the concrete to settle down readily between them.

After a layer of rocks has been bedded as described, enough additional concrete is poured into the hole and tamped down so as to cover and completely surround

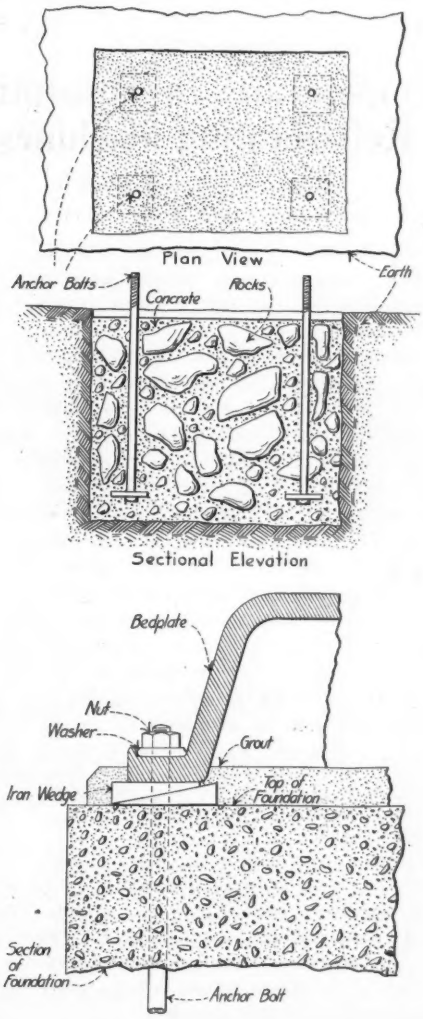


FIG. 1. PLAN AND ELEVATION OF FOUNDATION MADE WITHOUT FORMS

FIG. 2. ARRANGEMENT OF BED PLATE FOR GROUTING

the rocks. Then another similar stratum of rock and concrete should be placed, and so on, until the foundation is built up to the required height.

With a foundation like that of Fig. 1, forms are frequently unnecessary. Often the earth in which the excavation is made is compact enough to be self-sustaining, rendering the use of forms unnecessary. The arrangement of the bed plate when a machine is being

grouted on a foundation is illustrated in Fig. 2. About 1 in., more or less, should be allowed between the top of the foundation and the bottom of the machine bed plate, to permit the insertion of the wedges. It is usual to place a pair of wedges on each side of every anchor bolt. After the bed plate has been leveled and alined, all of the nuts on the tops of the anchor bolts should be turned down tight, binding the machine in place against the wedges. The wedges should preferably be removed from under the bedplate after the grout has set. The wedges may be either of wood or cast or wrought iron. Small wedges should be of wrought iron because small cast-iron ones are brittle and likely to break.

Temperatures in Absorption Refrigerating Machines

Effect on Pressures and Capacity. By W. L. Myer

RESOURCES necessary for operation of an absorption system are some form of heat, cooling water and a small amount of power for operation of the aqua pump.

Steam is universally used as the heating medium, although the combustion of oil or gas could be used. The quantity and temperature of steam can, however, be controlled much more easily. The steam cooling water, and refrigerating temperatures have a certain relation to each other. This relation can be seen in Starr's Properties of Aqua Ammonia in the Reference Tables. In this table, the per cent of ammonia by weight and degrees beaumé are given in the first column. The top lines give the pressure per square inch. The cross lines give the boiling point, degrees Fahrenheit. For example, aqua holding all the ammonia gas it will absorb at a temperature of 221 deg. F. and under 10 lb. ammonia pressure will have a concentration of 3.8 per cent of ammonia by weight or indicate 12 deg. on a Beaumé scale. The Beaumé scale is a hydrometer for testing the gravity of liquids lighter than water. Most tables and literature on aqua are based on this scale.

Suppose a machine is operating under 5 lb. steam pressure, has cooling water 60 deg. F., and a refrigerating temperature of 0 deg. F., which corresponds to 15 lb. evaporating pressure in saturated ammonia tables, the condenser or generator pressure will be about 120 lb. In steam tables, 5 lb. pressure corresponds to a temperature of 227 deg. F.

This temperature on the heating surface in the generator will bring the temperature of aqua to about 225 deg. F. and by referring to aqua ammonia table we find under a pressure of 120 lb. and temperature 224.9 deg. F., a concentration of 27.66 per cent or 25 deg. beaumé. This will be approximately the strength of the weak aqua coming out of the bottom of the generator for feed to the absorber.

After being cooled the weak aqua is injected into the absorber; the flow being broken up by a spray nozzle so as to absorb as much as possible. In practice, the aqua in an absorber will not absorb ammonia to full concentration. It is well it does not for, if the aqua absorbed to full concentration at the pressure and temperature of the absorber, the pump handling the aqua would become gas bound. The suction stroke of pump would have a tendency to reduce the pressure by drawing aqua through the connecting pipe and valves; taking a slight amount of pressure from the fully concentrated aqua, would boil some gas out of the solution and cause the pump to draw gas, become bound and hammer.

If the cooling surface in the absorber is sufficient to take care of the heat absorption and the cooling water at 60 deg., the temperature of the aqua will run about 65 or 66 deg. F. With this temperature and a pressure of 15 lb. a fully concentrated solution would be about 44 per cent. An absorber operating under the same conditions will usually have a concentration of approximately 36 to 38 per cent or corresponding to 29 to 30 deg. Beaumé. The difference between concentration of the weak aqua going to the absorber and strong aqua leaving the absorber is the carrying capacity of the aqua. In this instance it will amount to 10 per cent of the weight of the strong aqua. To understand more fully the relationship of temperatures in different parts of the machine, suppose the temperature of the cooling water in the last example was 80 deg. F. This will raise the generator pressure up to 165 lb. With this pressure and a temperature of 227 deg. for the steam, weak aqua will be approximately 34 per cent concentration or 28 deg. Beaumé. With water temperature at 80 deg. F., the aqua in absorber will have an approximate temperature of 86 deg. F., and under 15 lb. pressure will have a full concentration of 38 per cent, or practically have about 35 per cent. This will be too close to the boiling temperature of the weak aqua coming from the generator to be able to absorb much additional ammonia gas, probably not over 1 or 2 per cent of the weight of aqua handled, which would be impractical. Under this water condition it would be necessary to raise the pressure, likewise temperature of generator steam to operate the refrigerating machine.

It should be borne in mind that the above figures are subject to error in regard to temperature differences. There are so many factors to be considered that each machine condition needs considering separately. The point brought out is that the warmer the cooling water the higher the steam temperature. When figuring on using the latent heat of exhaust steam from some reciprocating steam machine, the question of steam pressure and corresponding temperature becomes important. The pressure of the steam should be as low as possible for efficiency of the reciprocating engine or pump, but at the same time must have a sufficient temperature to meet the conditions of the absorption machine.

A correspondent states that he is expecting to overhaul his boiler plant and will need to replace six 66-in. by 16-ft. h.r.t. boilers. Any reader having boiler equipment that might he used in replacing this plant will be placed in touch with him by sending particulars.

Wire screen is designed by the mesh, the number of openings per lineal inch, and the size of the wire in thousandths of an inch—The Gas Engine.

Taking Care of Double-Pipe Ammonia Condensers

TROUBLES ENCOUNTERED, REMEDIES EMPLOYED, PRECAUTIONS TO TAKE.

BY A. G. SOLOMON

DURING the past couple of years, I have had the opportunity of getting in close touch with several different kinds of ammonia condensers, and I find that the double-pipe type is the most neglected.

Most refrigerating engineers seem to believe that a double-pipe ammonia condenser should perform its full duty and receive no attention except the tightening up of a few bolts when a leak is noticed.

This style of condenser is in general use all over the country. In some places, the water conditions are such that the condenser has no chance at all after the first month of operation. In other places, the water contains so little sediment that a good cleaning of the tubes twice, or even once a year, is all that is required.

And one of the strange things about this condenser is that the most trouble generally happens in plants where quite cold condensing water is available. The reason for this is easily explained. Slowness of circulation of the water allows sediment to settle in the tubes.

With the cold water only a small amount has to be circulated to condense the gas and hold the condenser pressure down. This slow moving water will deposit whatever sediment it contains rapidly. In time the condenser pressure begins to go up and the pump is speeded a little. This will continue till the pump has to be run at a high speed to hold the proper condenser pressure. This means that more power than is necessary must be used to circulate the required amount of cooling water. Any increased condenser pressure means more power to drive the ammonia compressor. And we all know that power means fuel. If an engineer is fortunate enough to have charge of a plant where cold water is available, and only a small amount is needed, he should be sure to examine the inner tubes of the condensers for sediment. If the sediment is there, washing out should be resorted to frequently.

Cold water is one of the best things to insure economy in the operation of refrigerating machines. But when the condenser pressure begins to go up, while the condensing water remains at the same temperature, the reason must be found.

With the single-pipe atmospheric condenser, the formation of scale is readily noticed and its removal is attended to at once.

It is plainly evident that there must be scale or dirt collecting in the tubes of the double-pipe condenser, and one thing in favor of the double-pipe condenser is that hard scale does not form as rapidly as it does on the atmospheric condenser.

Where a condenser of each type is in continual service, both using the same kind of water, the single pipe will show hard scale long before it appears in the tubes of the double pipe.

But the slime and dirt which collect in the tubes are just as much an insulator as the hard scale on the single pipe, and in some cases even more so.

The scale on the atmospheric condenser forms heavily on the top pipes through which the hot gas first travels. Lower down on the coil the scale is not so heavy and at the bottom, where the liquid leaves, the scale is very light or not present at all.

But the counter current effect found in the double-pipe type causes slime and sediment to cling to the inner surface of the tubes where the water first enters the coil. This insulating effect will cause the liquid ammonia to leave the condenser at a temperature several degrees higher than it would if the tubes were clean.

In the passage of the water upward most of the sediment is deposited before the coils subjected to much heat are reached. This is the reason why hard scale is rarely found in double pipe condensers, but it must be kept in mind that the insulating effect of soft sediment is just as harmful as that of the hard scale on the atmospheric condenser.

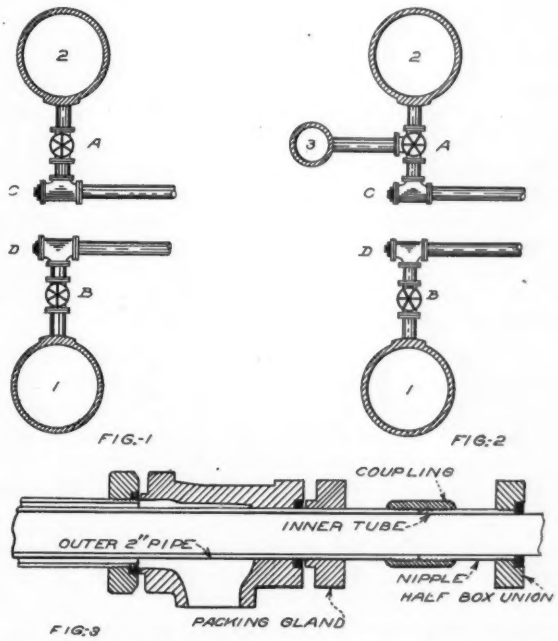


FIG. 1. COMMON METHOD OF PIPING DOUBLE-PIPE AMMONIA CONDENSER

FIG. 2. CONDENSER CONNECTIONS WITH WASHOUT HEADER

FIG. 3. CONDENSER TUBE REPAIRED AT END

Now it is seen that the cleaning of the double-pipe condenser is not a difficult task. In fact, it is much easier than the removal of scale from the single pipe, but it must receive attention.

In the first place, suitable water connection must be provided, so that flushing can be done quickly and often. (Figure 1 shows the common way.) Number 1 is the inlet water header; number 2 the outlet water header. A and B are three-way cocks. Both of these cocks should have short pieces of pipe screwed into the side opening, so that the water can be turned away from the condenser, and so prevent rusting of bolts and nuts. C and D are not ells, but tees, with a plug in the opening looking out. The reason for the plugs will be explained later.

By changing the position of the cocks, water can be sent directly through the coil and to the sewer. Each coil can be flushed both from top to bottom and from bottom to top. The reversing of the flow of water and the free opening to the sewer will wash out the sediment that would otherwise cling to the tubes.

This manner of flushing is all right when the water is fairly clean, and if it does not contain much sand or mud.

Where the water is bad, however, the following will be found to be the best way for washing. A pump should be used so that sufficient pressure can be had to force the water through rapidly. (Figure 2 shows the connections.) This diagram is the same as Fig. 1, with the addition of the washout header, 3, or the discharge line from the washout pump. The suction line to the pump can be taken directly from the outlet water header of the condensers. A relief valve should also be put in the discharge from the pump, so as to relieve the pressure when the cocks are being changed. A pump capable of holding 100 lb. pressure will be found to give the best satisfaction, as with this pressure every bit of sand, slime and sediment will be washed out clean. If this manner of washing out the tubes is resorted to, and the operation repeated as often as necessary, hard or troublesome scale will form very slowly, even though the water contains large amounts of scale forming sediment.

There are plants scattered throughout the country where the double-pipe condensers are washed out with 100 lb. pressure every day, and neglect to do so has shown a very apparent loss in capacity and increase in cost of fuel per ton of refrigeration produced.

Next in importance to the washing is the scraping or brushing of the water surface of the inner tubes. A few years ago this was not an easy matter, for suitable brushes were hard to obtain. Now brushes made of stiff steel wire are to be gotten which fit the inner tubes snugly, and which remove even hard scale, if such has been allowed to form.

The steel wire brush is fastened to a length of ½-in. pipe, and used just like the scrapers used for the removal of soot from the tubes of fire-tube boilers.

Some condensers are surrounded by walls, so that a long handle cannot be used. In such case the handle is made up of short lengths of pipe, fastened together with couplings.

Of course, the return bends on one end of the condenser must be removed when scraping is done. In most makes of the double-pipe condenser, the removal of the return bends is simple, as they are made on the pipe with a regular box union with rubber gaskets.

The top and bottom pipes are provided with plugged tees so they can be brushed the same as the rest.

As the return bends are taken off, they should be laid in a convenient place, and in the position in which they are removed. This will insure their being replaced where they belong. The return bends are supposed to be all the same so that they will fit anywhere, but I have found it better to put them back where they came from. Graphite and oil should be used on the threads of the unions, so they can be easily removed next time.

The gaskets in the unions can be used for a long time, and new ones can be made from such scraps of rubber as accumulate around any plant.

The outer pipes of the double-pipe condenser very seldom give any trouble. As there is no water flowing over them one coat of paint a year will keep the pipe like new for many years. The bolts holding the ammonia return bends to the pipe flanges, and also the bolts holding the packing glands in place, can be kept from rusting by a coat of paint and by preventing any water dripping on them. There is no excuse for leaking unions on the water return bends any more than leaks at any other unions. Stop all leaking and dripping as soon as it occurs and it will save future trouble.

The only part of the double-pipe condenser that seems to give out is the inner tubes between the packing gland and the return bend.

When a leak starts at this place, it is common practice to put in a new length of pipe. This is not necessary, and is costly. The defective tube can be taken out and the bad end cut off and threaded. Then use a coupling and the proper length nipple, and it is as good as a new tube. Couplings and nipples can be used at both ends if necessary, so long as the tube is good where it extends through the stuffing boxes, and the outer pipe. (Figure 3 shows a tube repaired at the end.)

If it is noticed that the exposed parts of the inner tubes are pitting or rusting, they should be scraped clean and two or three coats of graphite paint put on. If this precaution is taken when the condensers are first put up, a great deal of future trouble and expense will be avoided.

When an engineer takes charge of a plant which has been in operation for some years, he is certain to inspect the boilers thoroughly at the very first opportunity. This is the proper thing to do, as any defects found and remedied and any dirt and scale removed tend toward safety, economy and uninterrupted service. Careful inspection of every part of the ammonia condenser is just as necessary to secure favorable results from the entire plant.

One very important thing about the care of double-pipe condensers is the prevention of freezing during cold weather. It is not enough simply to stop the circulation pump and open the drains. All the water will not drain out of all the inner tubes. The water must be blown out.

To accomplish this, an air line must be connected so that air can be turned in at the top of the coils and the water forced out at the bottom drain cock. If the condenser is equipped with the washout pump (before explained), all that is necessary is to connect the air line into the discharge line of the pump. Then when the coils are to be drained, set the cocks in the position used when washing the coils, and turn on the air. This is the only sure way to guard against a freeze-up and the resultant bursting of tubes.

If the condenser is to be out of service all winter, it is best to mark and take off all the return bends. Or, if there is any reason why this is not done, the water headers to and from the condenser should be disconnected. This precaution is taken to guard against water entering the tubes through leaking valves or the careless opening of the valve.

Now, if the condenser has not been properly drained and a freeze-up does occur, there is only one right way to deal with it.

We will say that the plant is shut down during the nights and operated during the day in the winter. One very cold morning the engineer has good reason to believe that the condensers are frozen up. He must take off some of the water return bends in different places. If the tubes are found to be full of ice all the water return bends must come off, and also the ammonia must be pumped out and stored in the coils of the ice tank or some other part of the system. Do not pump a vacuum on the condenser, for the chances are that some of the tubes are split.

Most likely by the time the return bends are all off, the leaking tubes will be noticed by the ice melting out of them. Very little ammonia leaking will melt ice.

If the inner tubes were all found full of ice, and no leaks are noticed, the chance is good that the leaks will develop later. The expansion of the water while freezing exerted a tremendous strain on the tubes, and the seams of the pipe are weakened. Do not take the risk of losing ammonia and perhaps shutting the plant down during the summer season. Go at the condenser right away, and be sure it is all right.

I saw a case of this kind where several tubes had to be put in during the hot weather. A lot of ammonia was lost and many tons of much needed ice were not made. Tubes that were taken out showed plainly that the freeze-up had been the cause of every failure, as these tubes had been bulged, but had not quite split, and began to leak after the condenser had been in operation about a month after the beginning of the season. To be sure that just this does not happen, every inner tube must be taken out and examined for bulged spots, which are weak and liable to give out.

Take off the half unions at each end of the tubes and remove the packing gland. These glands must be handled with care, as they are easily cracked. They may be stuck on the tube or to the ammonia return bend. Clean the end of the tube so the gland will slip off after it is loosened. Then, with a wrench, turn the tube back and forth, and at the same time lightly tap the gland with a hammer. It will come loose without much trouble. Next remove the rubber packing, or slip the tube out and remove the packing afterward. Some of the tubes will refuse to come out through the ammonia return bend casting, owing to the bulges made by the expanding ice during the freeze. The quickest, and in many cases, the only way to take out a bulged tube is to remove the ammonia return bend, and slip it off the tubes. It will save time to do this as soon as a tube is found that does not come out easily.

As the tubes are taken out, stand them on end in a warm place to dry. Then hammer them lightly to remove scale and dirt. Next cap or plug one end and connect the other end to an air line, and test out with not less than 100 lb. pressure. If possible, the lengths should be submerged in a shallow trough of water while testing. The smallest leak will show bubbles.

Any tubes that are bulged should not be put back in the condenser, even though they do stand the air test.

All this may seem like a lot of unnecessary work to some, but any engineer who has had experience with a frozen double-pipe condenser will agree with me that it is the only safe way.

Save Ammonia for Munitions

NEED FOR ammonia by the Government in the manufacture of munitions makes it imperative that every refrigerating and ice-making plant should practice the greatest economy in the use of this material. The Government should have 20,000,000 lb. more of ammonia than all the plants in the country can produce; hence, at the best there will be a shortage.

The necessity for ice and refrigeration is recognized but it is quite within the possibilities that plants which are run inefficiently may be closed down, and only those operating at good efficiency, especially in locations where natural ice is available, allowed to continue. A pound of ammonia will make 20 hand grenades; so that even small savings are important.

Each plant will be called on to report to the Food Administration on the first of every month exactly what it is doing in saving ammonia.

It behooves every ice and refrigerating plant to give special attention to ammonia saving by getting rid of all leaks and making sure that every pound of ammonia used is doing its maximum of work. If shutdowns come, the most extravagant plants will, naturally, be closed first.

SHIPS ARE a prime factor in the winning of the present great struggle for Liberty and Democracy. The recent statements in Parliament show that the destruction of tonnage last year was much greater than the entire output of that year of the British and American shipyards. If this goes on, it will be impossible to supply our soldiers abroad, and our allies, with the food and material that they must have.

Special effort is now being made by the Emergency Fleet Corporation to enlist men for the shipyard work. Building these ships is as patriotic a duty as serving in the fighting forces. The shipyard worker must of necessity encounter some of the discomforts that the fighting man has to endure, but this is only his part in helping to win the war.

Volunteers for the shipping service are now being enrolled, and men are needed for every kind of trade. The organization of the men enrolling for this work will be known as the United States Shipyard Volunteers, and will be recognized as a distinct public service. A certificate of service will be granted to everyone who enrolls. The work is 8 hr. a day, rate of payment good, and the work done will be an effective help to the country.

Two hundred and fifty thousand skilled mechanics are needed. Local enrollment stations are established in practically all the large cities, or enrollment may be made by applying to the local representative of the State Council of Defense in each town or city. The enrollment stations are being handled by the United States Public Service Reserve of the Labor Department. If none of these agencies are available, enrollment may be sent to the Public Service Reserve of the Labor Department, or to the State Council of Defense in the nearest city.

More Power from Niagara

METHOD FOR GREATLY INCREASING POWER FROM THE FALLS DEVELOPEMENT WITHOUT SCENIC INJURY

WE have always advocated a greater utilization of the energy running to waste at Niagara Falls. Idealists who are more intent on the holiday pleasure of a few thousand visitors to the falls annually than the economic welfare of the country have influenced legislation to prevent further development. But a plan is now proposed which will help to perpetuate the appearance of the falls, and at the same time release some 3,000,000 hp. of energy for industrial use, thus saving 52,000,000 tons of coal a year, and helping to save our electrochemical plants, which are being forced to move elsewhere for lack of power. The data is given by C. A. Winder in the General Electric Review.

Total power available at the falls is estimated at 6,000,000 hp. Of this 5 per cent is on the United States side and 95 per cent on the Canadian or Horseshoe Falls. Some 250,000 hp. is now developed on the American side, and until 1914, about 150,000 hp. developed in Canada was transmitted to the States side of the river for use.

Increased industrial activity has caused the Canadian government to cut off a large part of this exportation of power, and industries on the United States side have found themselves with plants and equipment but no power to operate. Some have moved to the Canadian side, and ship their products into this country; some are idle. A 120,000-hp. steam plant has been built in Buffalo, to supply part of the deficiency, and is, of course, adding its part to increase the coal shortage.

Western powers can be developed for western needs, but current cannot well be transmitted East, and many electrochemical products cannot bear the freight expense of a long haul. Besides, the long haul will increase the car shortage troubles.

On the Canadian Falls there is too much water for the good of the falls. The immense volume passing is causing rapid erosion, some 7 ft. a year, which in another 100 years is likely to break down the great cliff and leave only a rapids in place of a cataract, thus destroying power possibilities and scenic effect together. The length of the Horseshoe Falls is about three times that of the American Falls, and it is agreed that the volume of water over the latter is sufficient for beauty and grandeur. If, therefore, the volume over the Horseshoe Falls were reduced to 15 per cent of the river flow, it would be sufficient for all scenic purposes, would reduce the erosion and danger of destruction, and would make available 80 per cent of the river flow for industrial energy.

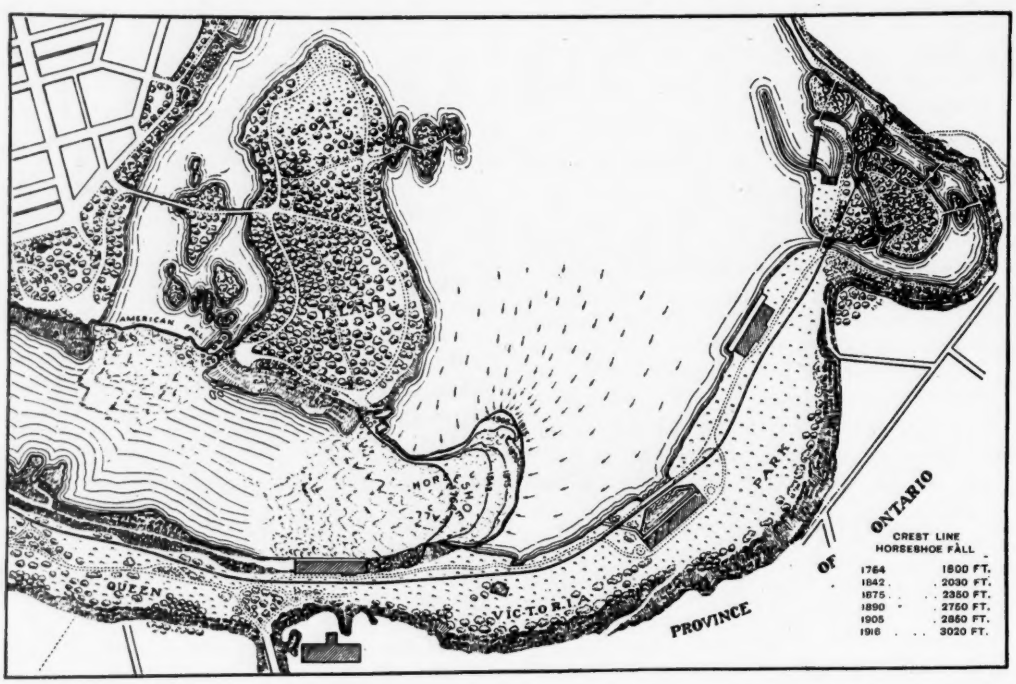


FIG. 1. COMPARISON OF AMERICAN AND CANADIAN FALLS, SHOWING RAPID EROSION OF THE LATTER

It is proposed to build submerged dams in the river, some 3000 ft. above the crest of the falls, so as to distribute the water evenly over the crests of American and Canadian sides, which would permit the use of some 60 per cent of the water, while spreading the balance over the entire cascade so as to give an effect equal in grandeur, greater in extent and less destructive than the present conditions. This still allows 40 per cent of the water to flow over the falls, which is twice what is

estimated as necessary to maintain the scenic beauty; so long as it is equally distributed.

Electrochemical products are essential to winning the war, and development of Eastern water power is vital to the electrochemical industry. All waterpower development is urgent to conserve our coal supply and overcome the shortage of coal and transportation. But legislation by Congress is needed to permit this improvement; and such legislation will be in accordance with the will of the people. It is important, therefore, that congressmen hear from their constituents in positive advocacy of this policy to economize our coal resources, assist our industries and aid our government in carrying the war to a successful conclusion.

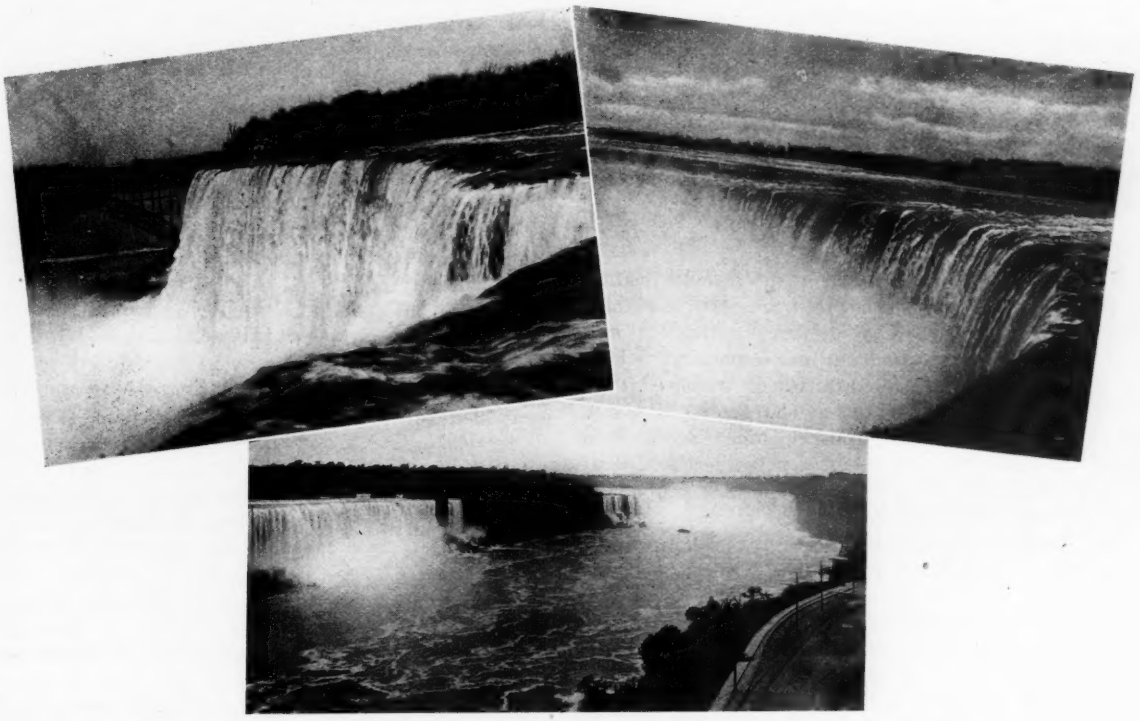


FIG. 2. VIEWS OF FALLS, SHOWING FLOW OF WATER AND EROSION OF HORSESHOE

Advantages of Direct Connected Motor Jack Shafts

By D. R. Shearer

WHEN connecting electric motors to line shafts or other machinery, it is frequently found necessary to use a long heavy belt or a vertical drive with tension idler, and in many cases after such a drive is installed the bearings of the motor will be found to heat excessively or wear much faster than bearings under normal operation. This will be found to be true, especially in regard to motors of 50 hp. and above, and it is these motors in which bearing replacement proves expensive and shut-downs from hot bearings may mean considerable production loss. When belted motors are placed in hard service, it is difficult to fasten the frame securely to the foundation and much vibration often results from this cause. Naturally, vibration is hard on the entire machine, but more especially the bearings, and should be prevented even at considerable initial expense.

Troubles which may arise from severe belt service on electric motors may be prevented by placing the driving pulley on short jack shaft between two heavy ring oiling bearings and then connecting the motor shaft directly with the end of the jack shaft by means of either a flexible or flanged coupling. When the drive is connected in this manner, the belt pull and belt vibration are taken up by the jack shaft and its bearings. The motor only has to produce the torque on the shaft and is thus relieved from all vibration and bearing strain. If the motor and jack shaft bearings are placed on a concrete foundation or are built together with channel and I beams of structural steel, a solid flanged coupling will be found satisfactory for joining the shafts; but if some other method of setting is necessary, the flexible shaft coupling will give the best satisfaction. This method of setting belt driving motors is especially desirable in those cases in which a large motor is used for driving either a large machine or an entire plant; or where any motor is used in driving some machine directly overhead, since an overhead drive with vertical belt tends to lift the motor shaft against the top of the bearings, which wear rapidly when so used.

An order authorizing construction of a water-power dam at Mussel Shoals, Ala., was signed by President Wilson recently. The dam forms a part of the $60,000,000 project for a government plant for fixation of atmospheric nitrogen to be used in the manufacture of munitions and fertilizer.

Help Solve the Transportation Problem

SUGGESTIONS TO SHIPPERS BY THE NATIONAL ORGANIZATION OF BUSINESS PAPERS

GROWING menace of the freight transportation situation has induced the Associated Business Papers, Inc., New York, through their Executive Committee, to formulate a plan for definite, practical co-operation by shippers to relieve terminal congestion and keep freight moving.

The following plan calls for action, now, and shippers everywhere are urged to bring it to the attention of the proper organizations for that purpose.

To win this war we must do things. Do them quickly, with less labor and less waste. We must increase valuable activity and decrease wasteful activity. We are at present suffering from a decrease of activity all along the line. This decrease comes from the inadequacy of the distribution system.

GOVERNMENT NEEDS YOUR CO-OPERATION

NEITHER the efficient control of government bodies, nor the wisdom of the railroad men can solve the whole problem. A large part of the difficulty is the local and short haul difficulty, resulting in congestion which extends back into the main arteries of transportation. At the present time the interest charges on goods in transit frequently amount to very much more than double the cost of the transportation, while the cost of waste, due to inability to secure materials and ship goods, runs into much larger figures.

For these reasons all men who secure their livelihood from the production of materials or goods and the sale of those products, should be interested in pushing for these items, which will enable us to build up an adequate transportation system.

It is time to quit kicking about rules which are established in the endeavor to clean up the situation, and to co-operate in such a whole-hearted and intelligent way that the tangle of transportation difficulty may be more rapidly untied and the situation cleared in record time.

It is recommended for this reason that, generally speaking, the shipper should be urged to foster movements in the following directions:

FOR THE IMPROVEMENT OF RAILROAD SERVICE

THE PROVISION of adequate rules to secure the full efficiency of transportation service.

2. This includes establishing proper charges for freight and demurrage and the enforcement of equitable rules for loading and unloading, shipping and packing.

FOR THE HIGHWAYS

THE EXTENSION of paved highways.

2. Provision for keeping these highways open at all seasons.

3. Proper provision for the maintenance of these highways.

FOR THE WATERWAYS

THE CONSTRUCTION of barges and small tow boats to provide for the adequate use of existing highways.

2. Provision for putting into shape existing waterways that have been allowed to become obsolete.

3. Provision for the wise extension of these waterways to correlate with the railroad system.

As a measure of relief from the present congestion, it is recommended that the shipper be advised that he can materially aid himself in the improvement of his own transportation conditions and the elimination of the excessive costs of not being able to do business, by carrying out the following suggestions:

IN CONNECTION WITH THE RAILROADS

CO-OPERATE and put it over. Do not kick at changes.

2. Load and unload promptly. Do not wait for a convenient season.

3. Load to capacity.

4. Do not reconsign en route. Decide the destination before the goods leave.

5. Pack securely and mark plainly.

IN CONNECTION WITH THE HIGHWAYS

MAKE A SURVEY of all the incoming and outgoing freight handled within zones of 10, 25, 50 or 75 miles from your city.

2. Ship all goods to be delivered within the above zones over the road by motor trucks.

3. Demand that all goods to be shipped to merchants in your city and originating within the zones mentioned be delivered by motor trucks.

4. Make a census of all motor trucks in your town available for this work.

5. Take up with your local offices of the national express companies and your local haulage and express concerns as to how far they can extend their present delivery routes.

6. Select a committee of the best traffic managers of the concern in your city to lay out a detailed plan to suit your own local conditions and determine upon the fair rates to be charged.

7. Arrange for a sufficient number of receiving platforms or warehouses where you can use horse wagons and motor trucks up to 3-ton capacity to deliver and set down goods, leaving for the larger trucks the running between the main points in the zones. Do not try to make the trucks running overland between the main points do pick-ups and deliveries. It cuts down their efficiency and makes the maintenance of schedules impossible.

8. Put some trucks in the overland haul work on definite leaving schedules so that goods can be delivered to the receiving platforms or warehouses in time to make up full loads to any given points.

9. Arrange a Return Loads Bureau. Arrange with the local telephone companies to give your regular telephone number to any inquirer calling up and asking for Return Loads Bureau. Post notices in the offices of all of your merchants that you have established a Return Loads Bureau. Post similar notices in conspicuous places in the smaller towns and cities through which trucks running to or from your city will have to pass. This will enable your trucks and those of private truck contractors doing this kind of haulage and entering your city to quickly collect loads to be transported to their home cities.

10. Bring all pressure to bear upon your mayor and the governor and thence to your highway commissioners to keep all the main highways leading out of your city open.

11. Bring all pressure to bear on the proper authorities toward the resumption of the construction of main line highways at the earliest possible moment this spring and for a proper maintenance of the roads all year around.

IN CONNECTION WITH WATERWAYS

SECURE INFORMATION upon transportation available on existing waterways covering short hauls.

2. Get behind the movement for immediate production of barges for the large canals, such as the Erie barge canal, which would relieve the freight situation between the lakes, coal regions and the important centers on the Atlantic seaboard.

3. Take up with the traffic manager of your business and the traffic expert of the local chamber of commerce the possibility of the use of waterways for any part of your freight movement and arrange shipping plans accordingly.

Cleaner Coal

EVERY man who has burned coal during the past winter has known that he was having to handle a large amount of slate, rock and dirt. This was evident from the appearance of the coal and from the amount of clinker and ash taken from the ashpit.

In a lecture delivered by E. G. Bailey before Johns Hopkins University, Baltimore, Md., in the J. E. Aldred Lectures on Engineering Practice, attention was drawn to the cost of handling this dirt, which is estimated to have totaled some 30,000,000 tons, and to the loss in supply of good coal due to tying up cars with hauling this rubbish.

Mr. Bailey made it clear that so long as the price of coal is fixed by the government and no account taken of quality, this condition will continue, and as much dirt as can be passed will be found in the coal shipments, because the dirt and slate weighs more than good coal and sells for the same price.

As a remedy, it was proposed to establish sampling stations at the principal shipping points, and test the coal from all mines at frequent but irregular intervals, so that the mine operator cannot tell what cars are likely to be sampled. A price differential should then be established, or possibly 5 to 10 cents a ton for 1 per cent of contained ash and as much as 25 to 50 cents a ton for each 1 per cent of extraneous ash which is mixed with the coal as dirt, slate or rock. Washing, picking, and other methods of eliminating impurities add a cost of 10 to 50 cents a ton in preparing the coal, hence a differential as proposed would make it an object for the mine operator to ship clean coal.

As pointed out by Mr. Bailey, this sampling routine can be established in a few months at comparatively slight cost, will ensure that cars and locomotives hauling coal are all usefully employed in delivering heat units rather than dirt, will improve the efficiency of the boiler furnaces, and eliminate much labor in firing and in handling ashes.

This will not relieve the man who burns the coal from the obligation to use it efficiently, but it will give him a better chance to get efficient operation in his plant.

CARL HERING states that more rapid conduction of heat from flame to water through a metal wall may be secured by introducing an artificial resistance on the flame side of the wall, thus increasing the temperature head through the wall. Present results indicate that this resistance should be increased only to the point where the flame side of the wall has a temperature halfway between those of the flame proper and the water, which for boiling water would be a dull red heat for the iron.

Lugs on the flame side are suggested as the practical method of introducing such a resistance, giving them such length and diameter that the ends next the flame will be kept at a dull red heat. Shape and spacing of the lugs is important, as it is necessary to get free circulation of hot gases between them. A slightly conical form, with the bases covering practically the whole surface of the wall, seemed to give good results.

Tests with lugs of the same diameter but different lengths showed that above a certain length the heat flow decreased. For lugs of a given length but different diameters, the smallest lugs practical gave the greatest flow.

Comparison of rate of heat flow showed an evaporation of about 17 lb. per sq. ft. per hr. for a plain wall as against 467 lb. per sq. ft. per hr. for the best arrangement of lugs tested. Further research is needed before the factors that determine the efficiency of this method are fully known, but the results seem to indicate the establishment of the principle that addition of lugs to the flame side of a water heating surface will increase rapidity of heat flow.

THERE IS a good opening in Jamaica, W. I., for small electric plants furnishing light for isolated country houses and power for doing the ordinary operations on the farm, such as grinding, pumping water, making butter, etc. Owing to the lack of development of water power here, electric current is available only in the larger centers, and there is a good demand throughout the island for individual plants at a moderate price. There is one outfit on the market at present which retails at about $400 and is capable of carrying 20 to 30 18-candlepower lights at 32 v.

The outfit should consist of a kerosene engine and a dynamo mounted on the same shaft, preferably, and a storage battery. The operation should be as simple and as nearly automatic as possible. Only oil-burning engines should be considered, as gasoline is altogether too expensive at the present time. Attention should be given to the method of packing and shipping so that the outfit can be set up by an ordinary mechanic.

"RICE POLISH," the product of the process of polishing brown rice to get the familiar white product, is a highly concentrated food, even more nutritious than the rice itself. It adds food value to bread and is excellent for pancakes, graham bread and similar dishes. Also it is inexpensive, the price at present as sold in bulk being about 3 cents a pound.

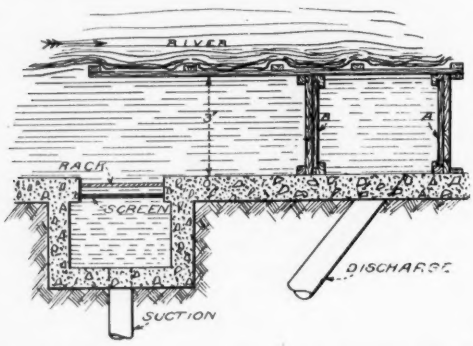
Protecting Intake Racks

THE ACCOMPANYING sketch shows a cheap and convenient method of keeping ice from collecting on intake racks in front of condenser wells.

One of the hard jobs in a condensing steam plant, located in the north, is keeping the rack clear of ice which has a habit of collecting on the very days it is most disagreeable for men to work out of doors.

By building a wooden fence, as shown, with gates at A and B it is easy so to regulate the flow of the warm discharge water that enough of it will return to the racks and melt the ice.

The fence is built of 2-in. plank with 2 by 4-in. or 4 by 4-in. uprights, braced to the retaining wall or pipes driven into the earth deep enough to support themselves.



SHOWING METHOD OF DIVERTING WARM DISCHARGE WATER TOWARD FRONT OF RACKS

The fence will have to be put in during the summer when the water is low or, if water is taken from a canal as is the case at most of the mills, it can be put in any Sunday.

L. H.

Combining Indicator Cards

WITH THE UNDERSTANDING that all criticism should be constructive rather than destructive, that it should be given with friendly intent and without sting, and in the full belief that all men of sense will welcome genuine criticism and comment relative to anything they say or do, I offer the following concerning the article by G. S. Blankenhorn, page 163, in the Feb. 15 issue of Power Plant Engineering.

Mr. Blankenhorn's article deals with the method of combining indicator diagrams from tandem compound engines. He mentions the value of combining diagrams and explains very clearly how to do the work. He makes one statement that I do not quite agree with, and that is in the last sentence of the first paragraph, where he says that the proper receiver pressure can be determined only by means of a combined card. Of course, a combined diagram will show whether or not the receiver pressure carried, in any given case, is the best for economy; but I do not think it is the *only* way to determine what the receiver pressure should be. Perhaps it would be interesting to the readers to learn of another way of determining what receiver pressure to carry in tandem compound engines.

Some years ago, I was employed in a power station where there were eight tandem compound engines of 500 hp. each, boiler pressure of 140 lb. per sq. in., and at first running with 7 lb. per sq. in. receiver pressure. We were not sure about the receiver pressure, so decided to experiment, to learn whether we could not reasonably increase the pressure. This is the way we went about it: We selected one engine for the experiment, and attached indicators to the cylinders. It was known just what fluctuation of load was endured, and from that we determined the load carried by the engine for the longest period of time, and had the man at the switchboard maintain that load on the engine while the experiment was in progress.

Diagrams were simultaneously taken from both cylinders, with different receiver pressures. There was an excellent wheel adjustment mechanism on the low-pressure valve gear cutoff, which enabled us to change the receiver pressure quite easily at will. I might here mention that the engines were of the C. & G. Cooper make, Corliss, tandem-compound, condensing. The load on the engine was kept constant all the while.

We found that with 25 lb. pressure per square inch in the receiver, the terminal pressure in the low-pressure cylinder was lower than with any other pressure below 25 lb. At the same time, the governor balls floated in a higher plane than with any of the lower pressures. The low-pressure diagrams had almost needle-point ends—low terminal pressure. As before stated, the load was maintained constant throughout the experiment. It was agreed by those interested in the experiment that 25 lb. was the pressure to carry in the receiver of those particular engines to suit that load which was carried over the greater part of the day in each 24 hr. It seemed to us that the higher the governor floated with a given load the least possible amount of steam would be consumed to do the work. It was hard to get the watch engineers of the station to believe that a big mistake had not been made in changing the receiver pressure from 7 lb. to 25 lb. But, as time went on, and as the steam consumption of the station did decrease, they gradually became convinced that no mistake had been made. There were also two cross-compound condensing engines of the Allis-Chalmers make in the station, and the same method was applied to them. These latter

engines were 1500 hp. each. Had any mistake been made in increasing the receiver pressure in all these engines, developing a total of 7000 hp., it would surely have been discovered very quickly, but the discovery was in the other direction.

I am of the opinion that many, if not most, engines are run with too low a receiver pressure, simply because the erecting engineer leaves the engine with a 5 or 10-lb. pressure, and the engineer in charge does not like to change it for fear he will do something wrong. The load the engine is carrying has an influence on the receiver pressure that should be carried. The designer of an engine cannot always give instructions as to just what pressure to carry. He can only say what pressure to carry if the engine is only to carry the load for which it was designed. Practical conditions may require something different, and these conditions must be found out, and experimented with for the best results.

Finally, Mr. Blankenhorn does not say *how* you can tell, from a combined diagram, whether or not the receiver pressure is correct. Perhaps he will tell us in another article, as it is an interesting subject. Let us also hear from other readers concerning receiver pressure.

CHARLES J. MASON.

Knocking Exhaust Valves; a Temporary Gasket

I WAS INTERESTED in the manner in which A. A. A. stopped the knock in the exhaust valves of his Corliss engine. In his case this stopped the trouble, but does not do so in every case.

I have tried putting in shims made of phosphor bronze, bent about ½ in., as shown in Fig. 1. This, I believe, is safer than turning off the back bonnet, as it makes a tight fit without the possibility of binding. In some cases it has cured the trouble, but not in every case.

One of the principal causes of exhaust valve slamming is that cutoff takes place so early in the stroke due to underload or high steam pressure, that the steam expands below the pressure in the exhaust pipe, which, if exhaustes into a heating system or long, crooked pipe, may be a few pounds above atmospheric pressure, and the pressure on the exhaust side lifts the valve from its seat, and causes it to slam in closing. If this is the case, it can easily be detected by the indicator or by temporarily reducing the steam pressure to lengthen the cutoff, noting whether the trouble is stopped or changed. If this is found to be the cause of the trouble, the proper remedy is either to reduce the steam pressure to get later cutoff and higher terminal pressure, or give the exhaust more compression. It is not, as a rule, possible or advisable to reduce the boiler pressure, and in this case the proper adjustment of the valves is usually made.

The writer has had some trouble of this kind on high-speed non-releasing Corliss valve engines. In some engines of this type, the valve stem packing bears directly against the collar on the valve stem back of the tee head. The pressure in the cylinder holds the stem out against the packing; but if there is a vacuum in the exhaust pipe or cylinder, due to very early cutoff, the stem may slam endwise if there is any end play.

This may be prevented by pushing the bell crank up tight against the bonnet, or putting a shim in between the crank and bonnet. Tightening up on the packing if it bears on the stem will usually prevent this slamming, as it thrusts the stem and valve back against the back bonnet. A cross sectional view of this valve stem and gland is shown in Fig. 2. We are using several engines of this type, and use a semi-metallic packing in the stems.

In some high-speed non-releasing Corliss valve engines it is sometimes difficult to get the engine to run quiet at all loads. It may run quiet at full load or overload, and rattle and knock at light loads, or possibly the reverse may be the case. This trouble can usually be eliminated or reduced by using the indicator, and experimenting with the valve setting until the best running conditions are obtained.

In reading C. H. Willey's kink on making a temporary gasket, and the reason therefor, the question arose in my mind: How much did he actually save? As no data is given as to size, etc., it would be difficult to arrive at the exact saving without knowing the conditions. The high-pressure sheet packing would cost considerable more than low-pressure packing; but if the engineer was careful in cutting the gasket, he would only require a small quantity by weight; the corners and center might be used to cut smaller gaskets. It

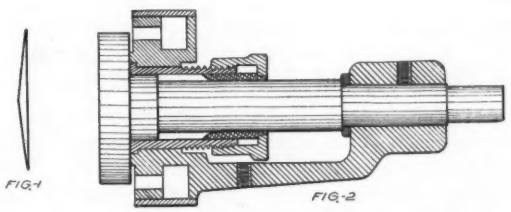


FIG. 1. BENT PHOSPHOR BRONZE SHIM
FIG. 2. CORLISS VALVE BONNET

required a long piece of lead wire to make the gasket as shown, and the price of lead is very high now. If high-pressure packing had been used, only the difference in cost between the low pressure packing and high pressure packing would have been wasted, and how would this compare with the cost of the lead wire? He might have used asbestos paper or card-board, which is still cheaper.

In some cases it is preferable to use a higher grade of material (and this applies to all kinds of supplies) at a considerably higher price, as it can be used more times or for a longer period or with less friction, as the case may be, and at less cost per year. I do not offer this criticism as questioning the motives of the chief in using a substitute in place of the high-pressure packing, but simply to bring out the point, that we not infrequently make a certain recommendation, or change of some kind on the grounds of "better company," "higher efficiency," "it's cheaper," or some other seemingly good reason when as a matter of fact, if the whole matter were closely figured out in detail, the advantage gained would be too small to bother with, or possibly it would have been cheaper than the matter was before the change. I can recall instances which have come to my attention where thousands of dollars have been spent to make certain changes which were made after thoroughly considering the case, and after the changes

were made it was found that the cost was greater than before. One instance in which this frequently happens and which involves a considerable amount of money, is substituting central station service for isolated plant service.

In referring back to Mr. Willey's kink, it is a good one, and one that might be of considerable value to some engineer who was forced to make repairs, and when he got ready for the gasket found that there was nothing of which to make it. The only point which I do question is the chief's statement of expense.

To illustrate this in another way: A long line of 12-in. high-pressure piping was being installed, and the flange gaskets were being made of a high grade, high priced sheet packing, and several yards were required for the job. The center of these gaskets was large enough to make flange gaskets for a low-pressure 4-in. line, but could not be used as it was too expensive, and a cheaper grade of packing costing about one-half as much was used. These discs, about 10 to 15 lb. in all, were taken to the stock room and piled on the shelf. A few of them were used, but at the end of a year they had became so dry and hard that they were useless and were thrown away. Where was the economy in using the cheap packing in this case? It appears to me that the total cost of the low-pressure packing was wasted by not using the high priced gasket instead of buying the low-pressure packing. J. C. HAWKINS.

Purifying and Heating Feed Water

UP-TO-DATE POWER PLANT managements have recognized the necessity of adopting the most effective methods of purifying and heating the water before it enters the boilers. The reason for this preliminary purification and heating is that it not only saves coal and adds to the life and durability, but it also reduces the cost of cleaning the boilers.

Water, depending on the source of supply, the rainfall and the seasons, holds in suspension organic or inorganic matter in various quantities; also chemical salts are held in solution. This suspended matter forms boiler scale only by being cemented to the boiler by other materials.

It is far better to remove the impurities from the water before it enters the boiler than to inject various compounds to neutralize the impurities. If such compounds are injected into the boiler it becomes necessary to remove the solid matter or grease by occasionally emptying the boiler and washing or scraping out the sediment or by the use of the bottom or surface blowoffs. While the grease or solid matter is allowed to accumulate inside the boiler, considerable loss in efficiency ensues.

This may interest Mr. W. T. McF., whose letter appears in the Feb. 15 issue, page 178; however, I am not entirely familiar with his particular case and only hope that he may from this obtain some aid in the way of an answer to his question.

Water intended for use in boilers may be purified in any one of four ways, namely, by settlement, by chemical means, by filtration and by heat. Filtratoin will remove impurities such as oil and grease, and earthly matter in mechanical suspension, but will not remove substances dissolved in the water. The water may be purified by heating to a high temperature, thus causing most of the scale-forming substances to become insoluble and precipitate. The scale-forming substances and corrosive acids may be made harmless by chemical treatment, which may be applied either before or after, preferably before, the water enters the boilers.

Sometimes the feed water is highly impregnated with incrusting materials, such as magnesia, carbonates and sulphates of lime; in such cases it is preferable to use a live steam purifier, but let me add that the live steam purifier should be used as a last resort, as it is much more economical to use sources of waste heat, if possible, for heating the feed water. Many of the impurities are precipitated and form scale when the water is heated to the temperature corresponding to the steam pressure maintained in the boiler, and the use of the live steam purifier is to precipitate the impurities before the water is fed into the boiler. There are a number of these purifiers on the market, each having its own merits. Often the water contains in solution such ingredients as can be neutralized or rendered harmless by the addition of caustic soda or kerosene before the water enters the heater. It may also be stated that kerosene fed into the boiler by a suitable appliance has the effect of loosening scale and preventing its adherence to the tubes.

C. C. H.

Commutator Trouble

I NOTICED the query on page 181 of the Feb. 15 issue in which M. E. W. tells of his trouble with sparking of a small exciter. Although the answer is given, I offer the following to help M. E. W., as I believe he is right and should be given a chance to try his remedy.

With modern, especially high-speed machines, the fault he suggests is common. The writer has seen a number of makes of machines in various plants, and has also had experience with a number of them, working under different conditions as to load, etc., but having the same symptoms and all cured by undercutting. In each case, after undercutting, they needed no other attention (not even wiping) for from 8 to 15 mo., and then the slots were only scraped out a little to be sure of keeping the mica low. In most of these cases, graphite brushes were used after undercutting.

One reason frequently given for high mica being such a common fault is that the brushes may be all right electrically, but not all right mechanically, generally containing too little abrasive material.

The symptoms of high mica are as he gives them, and as he says, turning down does not cure the trouble. The results are the same with sandpaper. The smudge he speaks of is a most reliable index of high mica, and almost always appears in sections and rapidly spreads, as in his case. In case of high mica, if the point of a pencil is held on the commutator a rapid violent vibration is felt as the mica segments pass under the pencil. When the trouble first starts there will be a row of small bluish sparks along the edge of the brushes, not confined to any one set. The trouble develops rapidly and the sparks soon change to a violent and reddish type. The smudge is found in cases of poor contact, and if other conditions appear all right the trouble is almost surely high mica. This can be temporarily helped by using a soft sandstone on the face of the commutator.

but the only way to save the machine is to undercut. If the trouble were something else, turning and sandpapering would not be apt to help for a while, as it does in this case.

I hope M. E. W. can convince the others and be allowed to make a trial. WM. C. THORNE.

SPARKING at the commutator may be due to any of the following causes: Too much load; brushes improperly set; commutator rough or eccentric; high or low bars; brushes making poor contact; dirty brushes or commutator; too high speed; sprung armature shaft; low bearings; warm commutator; short-circuited or reversed armature coil; high resistance brush; vibration; belt slipping; open circuited armature; weak fields; grounds.

Space will not permit a detailed account of each trouble and its remedy, and as most of these troubles suggest their own remedies, the writer will only refer to brush and commutator troubles. Some carbon brushes are liable to give out paraffin when hot, which, getting on the commutator, insulates it in spots. A copper brush is apt to get clogged with oil, dust, etc. Use as thick a brush as is practical with a moderate speed of commutator surface, so that the time of reversal will not be too short. Brushes that are too thick cause sparking because the neutral region is usually quite narrow, and if a brush short-circuits a coil while in anything but a weak field, a strong current will be set up in the coil. Again, where a number of coils are simultaneously under commutation, they induce electromotive force in each other by mutual induction which also may cause sparking. Some brushes contain an excess of paraffin, and while they are cold move freely in the brush holders; when they become warm, the paraffin oozes out and causes the brushes to stick; they also tend to gum the commutator, making it dirty; also, a soft carbon brush will, as a rule, make the commutator dirty and smudgy, which causes sparking.

M. E. W. mentions cutting down the mica. It seems to the writer that the trouble is in the brushes being too soft or too oily, and not in high mica, as the commutator would be very soft to wear down so much in a few days as to present high mica. Slotting the commutator may help, but slotting is not so prevalent as it used to be. The writer would suggest taking this matter up with the manufacturer of the machinery, giving him the name plate data of the machine, and try a harder brush. Of course, the trouble may be caused by more than one fault, and if load conditions are O. K. and the motor tests out all right, trying a different brush would be the next best thing to do.

A. READER.

How Do They Figure It?

I MET WITH an interesting condition of affairs in a small western town last summer and will tell about it. Perhaps some engineer can explain how this water motor could be operated less expensively than the electric motor.

A woman had discarded her electric motor which she once used for driving her washing machine. Instead, she is now using a water motor operated by water from the city pipe line.

As it happens, nearly everything in that city is municipally owned—the waterworks, lighting plant, central heating plant, and telephone, etc. The power is generated in the central plant. Out of town about a mile and a half current is used for driving a motor which in turn drives a pump, pumping the water back about two miles into the city water tank. From there, the water flows back about a mile to and through this washing machine motor.

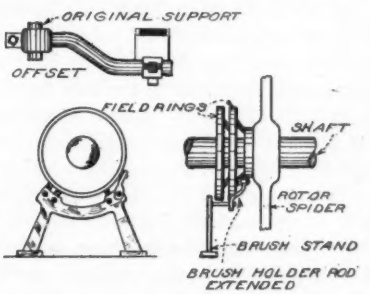
I do not know much about the efficiency of washing machine motors, but it is my belief that an electric motor is more efficient than a water motor.

The question is—how do they figure it? This woman's power expenses are actually less now that she has abandoned the electric motor.

N. G. NEAR.

Overcoming Rough Collector Ring Trouble

ONE OF the collector rings on an alternator in my charge had, since installed, become eccentric and as a consequence with any sticking of the brush in its holder severe sparking would occur whenever the low joint came around. Efforts on my part to eliminate the sparking by smoothing off the rough spot caused by this more or less continued sparking were of no avail.



ARRANGEMENT OF BRUSH HOLDER STAND AND BRACKET FOR SIDE RIDING BRUSH

Having no means at hand to grind down the ring or otherwise true it up, I decided as a temporary measure to swing one of the brushes around to the side of the ring, a scheme which I found worked exceedingly satisfactorily. The method employed will be understood by referring to the accompanying sketches.

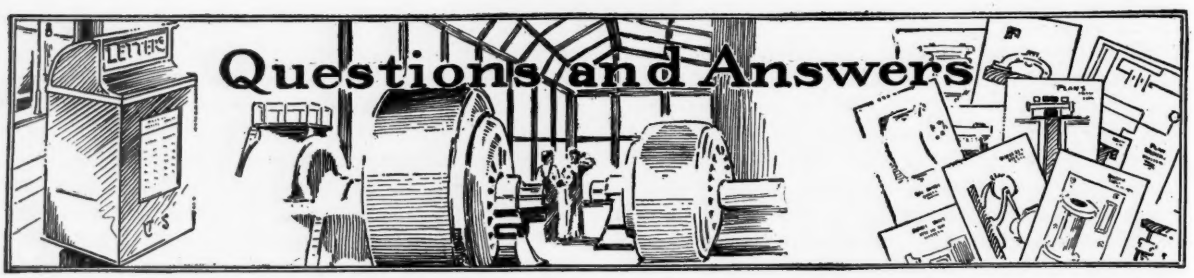
R. BRUCE.

Thawing Frozen Water Pipes

AFTER READING the question and answer on page 181 of the Feb. 15 issue relative to the thawing of frozen water pipes and having just had considerable experience with the same trouble, I concluded that readers might be interested in the scheme I employed.

I borrowed a "Compens-arc" from the local moving picture theatre and connected it to the secondary lines on the street near the frozen pipes and connected the leads marked for the lamp to the pipe in the basement and one to a valve or shut-off box across the street, and turned on the current, using the full capacity of the "Compens-arc," or 60 amp. In 1 hr. and 15 min. I had a ¾-in. pipe at least 150 ft. long thawed out.

R. B. RODMAN.



Re-establishing Residual Magnetism

I AM IN CHARGE of a Fairbanks-Morse direct current generator which operates at a speed of 1200 r.p.m. and which is rated at 15 kw., 160 v. This machine fails to generate at times and I find much difficulty in making it build up its voltage.

Would you kindly inform me as how best to re-establish the residual magnetism in the field when this disappears? If I do this by passing current from another generator or a storage battery through the field coils, must this be done while the machine is running?

E. J.

A. Evidently the machine you refer to is suffering from a case of chronic lack of residual magnetism. We would suggest that you disconnect the field coils from the armature and with the individual coils in series pass a current of, let us say, about 10 or 15 amp. through them, letting the flow continue for a period of about one minute. Then gradually reduce the flow until it is practically zero and disconnect the source of excitation.

You may then re-connect the machine and bring it up to speed and after which we are certain you will experience no further trouble. There is a possibility, however, that the flow of the exciting current was in the wrong direction, in which event the machine will not produce the correct polarity; that is, the negative lead will appear positive and the positive lead negative. This may be corrected either by again passing the exciting current through the coils, but in the opposite direction, or by reversing the field connections.

Preferably this should be done with the machine at rest and if available we would suggest using current from a low-voltage storage battery. O. H. H.

Boiler Setting Dimensions

PLEASE ADVISE ME how to set three 72-in. by 18-ft. return tubular boilers as to furnace construction and height of boilers from grates. We are burning soft coal, mine run, with about 13,900 B.t.u., have shaker grates, hand fired, 36-ft. grate surface and stack 120 ft. high by 54 in. in diameter. The boilers will be used two at a time to evaporate 60 tons water for distilled water ice.

A. B. H.

A. Looking over the data of the boilers which you have to set, we would recommend the following as dimensions for the furnace and setting:

The distance from the shell to the grate, at the rear, 52 in., set the front end of the grate about 3 in. higher. The distance from shell to bridge wall, 27 in.; from rear end of boiler to back wall, 26 in. Back and side walls, 20 in. thick, either made solid or built up with two 9-in. walls, having 2-in. space between filled with sand or some non-conducting material. Do not leave this as an air space. Bridge wall, 30 in. thick. The distance from shell to side walls, 4 in.

The furnace should, of course, be lined above the grate with fire-brick, preferably laid all with ends toward the furnace, as this makes a more durable and more easily repaired lining. It is well, also, to line the side walls in the combustion chamber, back of the bridge wall, with fire-brick, but below the top of the bridge wall the lining may be of ordinary hard-burned brick.

For the kind of material that you have, we would advise a mixing and combustion arch of fire-brick.

You will probably save something in radiation by setting two of the boilers in battery, and the third as a separate boiler. It is not desirable to set the third in battery, as this makes it impossible to get at the center boiler conveniently for repairs.

Your stack and grate surfaces seem to be all right, and the boilers have sufficient capacity to evaporate your water without any difficulty.

The material required for the setting of each boiler, assuming a full front setting, would be 2500 fire-brick, 16,750 common hard brick, 146 bu. of sand. 38 bu. of lime, and three barrels of fire-clay.

The rear brackets of the boilers will, of course, be supported on the side walls, and should have rollers under them to permit of expansion and contraction, and the back end of the boiler should be set 1 in. lower than front end, so that it will drain toward the blowoff pipe. A brick pier should be built to protect the blowoff pipe from the impact of the hot gases.

A. L. R.

Performance of Synchronism Indicators

WE HAVE two Allis-Chalmers turbo-generators, one of 140 kv.a. and the other of 240 kv.a. rating, both of which, however, operate at 3600 r.p.m. and deliver current at 440 v., 60 cycles.

When paralleling these machines considerable disturbance occurs between the two machines and when the synchronizing plug is withdrawn the indicator needle recedes from the "slow" and "fast" marks. The indicator is provided with one running and one starting plug and is of General Electric make.

Can anyone tell me how to overcome the trouble?

C. L. R.

A. When alternating-current generators are in synchronism, a synchronism indicator connected thereto will, or should if correct, indicate that the machines are in synchronism. If, however, the plug is removed, the instrument is no longer under the influence of these machines, or, in other words, it is "dead," and as a

result, due undoubtedly to an unbalanced condition of the revolving member, the indicating pointer will drop either in one direction or the other.

If your synchronism indicator is in proper adjustment and all connections are correct, we fail to see why you should experience any trouble when throwing your incoming machine onto the bus bars. The writer has operated a great many alternating-current generators, and has found from his experience that the best results may be obtained by so adjusting the speed of the incoming machine as to cause the synchronism indicator to revolve at a speed of about 2 or 3 r.p.m., and then throw in the switches by so timing them that they close the instant synchronism is indicated. If you allow the instrument to operate faster than 2 to 3 r.p.m., and you start to operate the switch at the instant synchronism is complete, due to the time element bound to be involved, you are unable to obtain quick enough action to cause the switch to come in on time. As a consequence, you will experience the trouble you mention.

If, on the other hand, you are certain there is nothing wrong with the method of operating you employ, we would suggest that you take up the matter direct with the General Electric Company, who, we are sure, would gladly do all in their power to help you overcome your difficulty.

Effective Clearance in Gasoline Engines

IN A GASOLINE ENGINE, will decreasing the clearance between the piston and head, thus increasing compression, increase the power of the machine?

J. E. K.

A. Reducing the clearance in a gasoline engine will increase the compression and will slightly increase the power of the engine, as it will raise the pressure after ignition. There is a point, however, beyond which this cannot be carried safely. If the compression is too high, it is likely to result in back-firing or pre-ignition, with possibly serious results.

With a heavy compression, it is usually necessary to have the ignition somewhat later than with a lighter compression, also the increase in compression and consequent increase in initial pressure after ignition may result in putting a heavier strain on the parts of the engine than it was designed for, and in this way cause rapid deterioration or even breakage of some parts of the engine.

A. L. R.

Variation of Horsepower with Cutoff

WILL YOU please explain how the horsepower of an engine increases by advancing the cutoff from one-fourth to one-half stroke?

A table I have gives the following: One-fourth cutoff mean pressure per pound initial, 0.59; terminal, 0.25; one-half cutoff, 0.84; terminal, 0.50.

J. P. V.

A. In order to answer your question in a comprehensive manner, it will be necessary for us, first, to take up the formula employed to determine the indicated horsepower of any reciprocating type of steam engine. This, as you perhaps know, is equal to P L A N $\div$ 33,000; where P is the mean effective pressure, in pounds per square inch; L, the length of the stroke, in feet; A, the area of the piston, in square inches, and N, the number of strokes per minute.

With a given speed, and as the values of L and A cannot, in any given engine, be varied, we find that this formula is directly proportional to the value of P, the mean effective pressure of the steam within the cylinder. The value of this factor is, in turn, proportional to the point at which cutoff occurs.

Let us assume that we have a boiler pressure of 100 lb. Under these conditions, and the engine cutting off at one-quarter stroke, the value of P will be equal to 0.59×100 or 59 lb. (from table showing ratio of mean to initial pressure). If, however, the cutoff is advanced to one-half stroke, the value of P will be increased to 84 lb. per square inch, and as a consequence, the horsepower developed will be increased proportionately.

Gear Calculations

WILL YOU please give me a rule for calculating size and speed of gears; that is, the driver and the driven?

C. J. H.

A. The relations of the size and speed of driving and driven gear-wheels are the same as those of belt pulleys. In calculating for gears, multiply or divide by the diameter of the pitch-circle or by the number of teeth, as may be required. In calculating for pulleys, multiply or divide by their diameter in inches.

If D = diameter of driving wheel, d = diameter of driven, R = revolutions per minute of driver, r = revolutions per minute of driven, RD = rd.

$R = rd \div D$; $r = RD \div d$; $D = dr \div R$; $d = DR \div r$.

If N = number of teeth of driver and n = number of teeth of driven, NR = nr.

$N = nr \div R$; $n = NR \div r$; $R = rn \div N$; $r = RN \div n$.

To find the number of revolutions of the last wheel at the end of a train of spur-wheels, all of which are in a line and mesh into one another, when the revolutions of the first wheel and the number of teeth or the diameter of the first and last are given: Multiply the revolutions of the first wheel by its number of teeth or its diameter, and divide the product by the number of teeth or the diameter of the last wheel.

To find the number of teeth in each wheel for a train of spur-wheels, each to have a given velocity: Multiply the number of revolutions of the driving-wheel by its number of teeth, and divide the product by the number of revolutions each wheel is to make.

To find the number of revolutions of the last wheel in a train of wheels and pinions, when the revolutions of the first or driver, and the diameter, the teeth or the circumference of all the drivers and pinions are given: Multiply the diameter, the circumference, or the number of teeth of the driving-wheels together, and this continued product by the number of revolutions of the first wheel, and divide this product by the continued product of the diameter, the circumference or the number of teeth of all the driven wheels, and the quotient will be the number of revolutions of the last wheel.

TODAY MAN is dependent upon man, and those who can mold and influence their fellow men stand out as dominant powers from the mass of humanity.

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Increase in Costs and Prices

Everybody realizes that costs are rising. The bills for groceries, for meats, for clothing prove this. The pay roll shows that costs of production must increase, for men need and are demanding higher wages to meet the higher living costs.

This, in turn, makes for still higher living costs, for the added wages must increase the selling price of foods, clothing, fuel, furniture or whatever is produced by the higher paid labor.

It is not our present purpose to discuss the outcome of this tendency, for it is a condition that has to be faced, and, for the present, little can be accomplished by theorizing about it. Some of the increased cost can be met by more economical methods of production, by saving wastes, and by improved machinery; but not all.

During the past three years, every popular magazine has raised its subscription price once, some of them twice. Cost of paper has doubled, wages and salaries have increased 30 to 60 per cent, postage has increased 50 to 100 per cent, and other materials used by the printer and publisher in like ratio.

Practically every newspaper in the country that sold for one cent has doubled its price.

By the strictest care, Power Plant Engineering has been able to continue to give its readers the exceptional value of a year's help, twenty-four issues for $1. But expenses are continuing to increase, and the limit has been reached.

It is important that a reasonable part of the income of a publication should be derived from subscriptions. If all the revenue came from advertisers, editorial independence would be lost. It is the platform of the editors of Power Plant Engineering that the interests of subscribers are their care, and that no advertiser or advertising consideration can influence its editorial policy. This we feel should continue, and to make sure that it does, the subscription price must be sufficient to cover the major part of the cost of producing the editorial contents. We feel that readers of Power Plant Engineering will wish its editorial independence to be preserved, and will recognize that, even at an increased subscription price, the help given them is worth many times what it costs.

The increase is made as small as actual conditions permit. Beginning with June 1, 1918, the subscription price for Power Plant Engineering will be $1.50 a year. Until that time, subscriptions and renewals will be accepted at the present rate, $1 a year.

Coal Economy a Permanent Necessity

While the country is just emerging from a coal crisis, it is well to reflect and profit by the experiences just passed through. First of all we have learned that it is not always possible to secure coal immediately when it is desired. Second, to insure ourselves against a shortage, plans must be laid far ahead of the time when the need will present itself. Third, those having financial control of power plants have been forced to recognize the needs of their plants for more economical equipment and management.

As pointed out by Professor Stoek of the University of Illinois at a recent meeting of the Chicago section

of the American Society of Mechanical Engineers, the crisis just past is merely an indication of what is to come unless more economy is shown in the use of coal in the future and greater foresight is used in purchasing.

Inasmuch as factories are now working to the limit of their capacity in most cases, it is obvious that only a comparatively small percentage of the power plants of the country can expect to make radical re-equipment before the next winter season is reached. Obviously the immediate course of action to pursue is to make an estimate of the amount of coal that will be required to carry the plant through the coming winter, provide a place in which to store it, select coal that will store without excessive heat loss and danger of spontaneous combustion, then contract for as early a delivery as possible of the desired amount of coal. By using coal which is mined nearest the location of your plant, transportation will be reduced to the minimum which is a factor well worth considering. Your equipment may not permit the use of such coal, but the possibility of using it should nevertheless be considered, and where necessary and practicable plans should be laid for equipping the plant to use the most available fuel at the earliest possible moment.

Using the fuel to the best possible advantage is the work of the power plant force and readers of Power Plant Engineering are familiar with the methods employed in the most efficient plants of the country. Considerable impetus, however, has been given to the matter of economy during the past few months, which has led to the radical recommendation by Joseph Harrington, at the meeting mentioned above, that the Government should supervise power plants and require a high standard of efficiency in operation. His plan would be to have plants inspected by experts to see that they are properly equipped with necessary instruments and that the operating force is competent and not neglecting its duty, the experts to give instructions when needed and compel the keeping of adequate records; where owners refuse to cooperate with the Government in making improvements they should be refused coal to burn.

In this democratic country of ours, this seems radical; yet we believe engineers would welcome such regulation as would make compulsory just those advancements in the industry for which most of us have been striving, and as for economy in the use of coal nothing would be more effective. It behooves every engineer to eat, sleep and think coal economy so that, whether regulation comes by natural shortage of supply or by Government distribution, he will be getting maximum results per pound of fuel used.

Third Liberty Loan

FOR opening subscription lists for the third Liberty Loan, Secretary McAdoo has set April 6, the first anniversary of the declaration of a state of war between the United States of America and Germany.

Every man, woman and child in the country must lend their available means to the Government in order that the war may be carried forward to a victory that shall establish the right of peoples to determine under what form of government they shall live.

Our boys are showing in the trenches in France that they can and will do their part. They are volunteering for the most difficult and hazardous duties. They are asking to stay at the front line trenches longer than the allotted time. They are meeting attacks more than half way. It is for us at home to show the same eager, steadfast will to win, and to put all our resources and energies at the disposal of the Government to back up those boys—our boys—who are gladly facing danger that their homes and country—our homes and country—may be kept safe.

Thrift and War Savings Stamps in place of frittering away small amounts for useless indulgences; Liberty Bonds for larger savings; these are our methods of "carrying on"; of standing fast to guard the trenches and of going "over the top" to win for democracy.

TWO FOOD PRODUCTS, not heretofore largely used, are advocated by the Food Administration to reduce cost of living. The pinto bean is a western product of which a good supply is grown, but on account of its mottled brown color, it has not been a favorite. It has food value equal to the better known white or navy bean, and is suitable for cooking in the same way. It is retailing at about 2 lb. for a quarter, as against 20 cents a lb. for navy beans. Canners are also packing them, a can holding 1¼ lb., and selling for 15 cents, as against 25 cents for a can of navy beans.

Another nourishing food is the southern cowpea, which is cooked when green in the pod like a string bean, and later when shelled is used like green peas. When dried, cowpeas can be boiled, baked with fat pork, and made into dishes with bread crumbs, vegetables or soups. They may be baked the same as beans by parboiling a quart for 5 or 6 hr. until softened, then put into a pot with pork, a tablespoonful of molasses and a small onion chopped fine. Cover with water and bake slowly for 6 hr., keeping the pot covered, except for the last hour.

AMERICAN-BUILT battle planes are now on the way to France. The first shipment is not large, but marks the overcoming of difficulties always encountered in beginning the manufacture of a new product, hence gives promise of rapid progress henceforth. These planes are equipped with the Liberty Motor, 12 cylinders, and in a recent test surpassed all records for speed and climbing for machines of that type.

It is interesting that for each plane in service in the air, two are required on the ground for repairs and overhauling, besides a training machine for every pilot who reaches the front, and a spare engine for each plane. Also every plane in the air requires 46 men on the ground to do the repair adjusting and supply work for the plane and its armament.

HEATING AND COOLING of furnace walls is continuous and cracks will form. It is a profitable expenditure of time to go over the boiler settings once a month with a candle flame to spot the leaks, paying special attention to the joints around fire and clean out doors, and around the breeching. Mark the leaks and fill them with elastic paint or cement, but don't assume that the places patched will never leak again. A saving of 10 to 25 per cent of fuel may easily be made by persistent following up of leaks.

New Wayne Curb Pump

ONE of the latest developments in oil handling devices is the 1918 curb gasoline and oil pump recently put upon the market by the Wayne Oil Tank & Pump Co., which discharges any predetermined quantity of liquid in a continuous, uniform stream and is operated by a continuous forward motion of the pump handle.

In this new pump, cams replace the gear and rack commonly employed; two reciprocating plungers are used and are so operated that the combined displacement is constant. A simple adjustment makes it possible to secure any exact unit of liquid. Two recording devices are attached to the pump—one 1,000,000-gal.

NEW WAYNE CURB GASOLINE AND OIL PUMP

meter keeps an accurate record of all liquid taken from the pump, the other is a pre-determined counter which enables the operator to obtain any quantity from 1 qt. to 20 gal. and repeat if necessary. A filter is incorporated in the head, which insures a clean liquid.

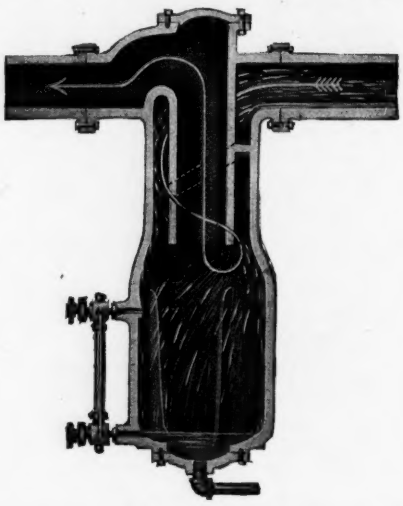
The pump stands 9 ft. 2 in. high and has a base 18 in. in diameter. The upper part of the cylindrical housing slides up and down, being counter-balanced by weights.

Stratton Air Separator

THE accompanying illustration shows the Stratton air separator for the removal of water from compressed air. Much difficulty is experienced in such separation and it is general practice to use an aftercooler to bring the air into a suitable condition for giving up most of the water which it contains, but such an aftercooler merely condenses the moisture and does not remove it.

The Stratton air separator is designed to remove this water. The construction is similar to that of the Stratton steam separator. Centrifugal force is utilized as the means of separating the water from the air. The air and water entering the separator are caused to pass through a helical path, which imparts a whirling motion to the air and the water. As the water is several hundred times heavier than the air, it does not make the turn as easily and is thrown out of the path of the air and against the wall of the separator, leaving a reservoir of dry air in the center of the apparatus. The helical path is so proportioned that large or small quantities of water swinging out of the curving air current meet the wall at an angle and slip smoothly along without the slightest spatter or splash, following close to the wall until the receiver space at the bottom is reached. At this point the swirling motion is checked by proper baffles, so that drainage may be easily accomplished.

This separator is useful on any compressed air line and is particularly applicable to sand blast machines and pneumatic tools. In the case of sand blasts, water in the air is very detrimental to operation because it causes the sand to pack and prevents it from flowing



SEPARATOR FOR THE REMOVAL OF WATER FROM COMPRESSED AIR

freely from the blast nozzle, resulting in faulty operation and necessitating periodic shut-downs for cleaning.

The Stratton air separator is suitable for a working air pressure up to 160 lb. per sq. in., and is made by the Griscom-Russell Co., of New York City.

News Notes

ON MARCH 27 to 29, a national conference on Labor Problems Under War Conditions will be held at the La Salle Hotel, Chicago, taking up the subject under four main topics.

1. Women Replacing Men in Industry.
2. Maximum Production From Men Remaining in Industry.
3. Function of Mechanical Equipment in Supplying Shortage of Men.
4. Readjustment After the War to Care for Disabled Men Returning.

Copies of the complete program can be had from Geo. C. Dent, Secretary, 327 S. La Salle St., Chicago, Ill.

H. P. CURTISS, formerly with the American Blower Co., has been appointed New England representative of the Clarage Fan Co., of Kalamazoo, Mich., and will have offices at 120 Milk St., Boston, Mass.

These tables contain data especially worked out or carefully selected that are vital to your work. You may need them at any time and should preserve them. A handy, serviceable, loose-leaf cover in which these tables fit exactly will be sent you for

These tables contain data especially worked out or carefully selected that are vital to your work. You may need them at any time and should preserve them. A handy, serviceable, loose-leaf cover in which these tables fit exactly, will be sent you for 30 cents in currency or stamps.

POWER PLANT ENGINEERING

STARR'S TABLES OF PROPERTIES OF AMMONIA LIQUOR

Line	% of NH_3 By Weight and Degree Baume	0	5	10	15	20	25	30	35
1	1	206.3	223.6	234.9	247.4	256.2	263.8	270.4	277.1
2	1.84-11°B	201.4	219.3	231.6	243.0	251.7	259.4	266.4	272.7
3	2	201.1	218.5	230.8	242.1	250.9	258.6	265.5	271.9
4	3	195.8	213.2	225.5	236.6	245.6	253.3	260.2	266.8
5	3.80-12°B	191.5	208.8	221.0	232.3	241.0	248.7	255.7	262.0
6	4	190.5	207.7	220.0	231.2	240.0	247.6	254.7	260.9
7	5	185.2	202.4	214.6	225.8	234.6	242.2	249.3	255.6
8	5.30-13°B	183.5	200.7	212.8	224.1	232.8	240.5	247.5	253.8
9	6	180.0	197.1	209.2	220.5	229.2	237.0	243.9	250.2
10	6.80-14°B	175.8	193.0	205.0	216.2	224.9	232.6	239.6	246.0
11	7	174.9	192.1	204.0	215.3	223.9	231.7	238.6	245.1
12	8	170.0	187.2	199.1	210.3	218.9	226.9	233.7	240.1
13	8.22-15°B	168.8	185.8	197.8	209.0	217.7	225.4	232.4	238.6
14	9	165.4	182.5	194.5	205.3	214.3	222.0	229.0	235.2
15	10-16°B	160.8	177.7	189.6	200.6	209.2	216.9	223.9	230.1
16	11	156.4	173.2	185.1	196.1	204.7	212.4	219.4	225.6
17	12	151.9	168.9	180.6	191.9	200.6	208.3	214.8	221.0
18	12.17-17°B	151.0	168.0	179.9	191.0	199.6	207.3	213.6	219.6
19	13	147.5	164.4	176.4	187.4	196.1	203.7	210.1	216.1
20	13.88-18°B	143.7	160.5	172.3	183.4	192.0	199.7	206.0	212.1
21	14	143.2	160.0	171.8	182.9	191.5	199.2	205.5	211.6
22	15	139.0	155.8	167.6	178.7	187.3	195.0	201.3	207.4
23	16	134.8	151.6	163.4	174.5	183.1	190.8	197.1	203.2
24	16.22-19°B	133.8	150.6	162.3	173.3	181.4	189.5	196.0	201.8
25	17	130.6	147.4	159.1	170.1	178.2	186.3	192.8	198.6
26	18.03-20°B	126.2	142.9	154.6	165.6	174.2	181.9	188.9	195.1
27	19	122.3	138.9	150.7	161.6	170.3	177.9	185.0	191.1
28	19.87-21°B	119.4	135.9	147.6	158.6	167.2	174.9	181.5	187.2
29	20	118.9	135.5	147.1	158.2	166.7	174.4	181.1	186.7
30	21	115.2	131.8	143.4	154.5	163.0	170.7	177.4	183.0
31	21.75-22°B	112.9	129.4	141.0	151.9	160.5	168.2	174.6	180.1
32	22	112.0	128.5	140.1	151.0	159.6	167.3	173.7	179.2
33	23.03-23°B	108.0	124.5	136.1	147.0	155.6	163.3	170.0	175.4
34	24	114.8	121.3	132.9	143.8	152.4	160.1	166.8	172.2
35	24.99-24°B	101.5	117.8	129.3	140.1	148.6	156.3	163.0	168.4
36	26	98.3	114.6	126.2	136.9	145.5	153.1	159.8	165.3
37	27	95.1	111.4	123.1	133.7	142.3	150.0	156.6	162.1
38	27.66-25°B	93.0	109.4	121.0	131.7	140.1	147.9	154.5	159.9
39	28	92.0	108.3	120.0	130.6	139.1	146.8	153.4	158.9
40	29	88.9	105.2	117.0	127.5	136.0	143.8	150.3	155.8
41	29.60-26°B	87.0	103.3	114.7	125.4	133.9	141.6	148.2	153.8
42	30	85.8	102.1	113.5	124.2	132.7	140.4	147.0	152.6
43	31.05-27°B	82.6	98.8	110.2	120.9	129.4	137.1	143.5	149.2
44	32	80.1	96.2	107.6	118.3	126.8	134.5	140.9	146.6
45	33	77.4	93.5	104.9	115.6	124.1	131.8	138.7	143.9
46	33.25-28°B	76.5	92.6	103.9	114.6	123.1	130.8	137.8	143.0
47	34	74.6	90.7	102.0	112.7	121.2	128.9	135.9	141.1
48	35	72.0	88.1	99.4	110.1	118.6	126.3	133.3	138.5

POWER PLANT ENGINEERING

PROPERTIES OF AMMONIA LIQUOR

Line	% of NH_3 By Weight and Degree Baume	95	100	105	110	115	120	125	130
1	1	328.5	331.7	334.8	337.8	340.7	343.5	346.2	348.8
2	1.84-11°B	324.1	327.3	330.4	333.4	336.3	339.1	341.8	344.4
3	2	323.2	326.5	329.6	332.6	335.4	338.2	341.0	343.6
4	3	317.9	321.2	324.3	327.3	330.1	332.9	335.7	338.3
5	3.80-12°B	313.4	316.6	319.7	322.7	325.6	328.4	331.1	333.7
6	4	312.4	315.5	318.7	321.6	324.5	327.4	330.0	332.6
7	5	307.1	310.2	313.4	316.3	319.2	322.1	324.7	327.3
8	5.30-13°B	305.8	309.0	312.1	315.1	318.0	320.8	323.3	325.9
9	6	302.2	305.5	308.5	311.6	314.4	317.3	319.7	322.4
10	6.80-14°B	297.7	300.9	304.0	307.0	309.9	312.7	315.2	317.8
11	7	296.7	300.0	303.0	306.1	308.9	311.8	314.2	316.9
12	8	291.7	295.1	298.1	301.2	303.9	306.9	309.3	312.0
13	8.22-25°B	289.7	292.9	296.0	299.0	301.9	304.7	307.2	309.8
14	9	286.3	289.6	292.6	295.6	298.5	301.3	303.8	306.4
15	10-16°B	281.0	284.2	287.3	290.3	293.2	296.0	298.5	301.1
16	11	276.5	279.7	282.8	285.8	288.7	291.5	294.0	296.6
17	12	272.0	275.2	278.3	281.3	284.2	287.0	289.5	292.1
18	12.17-17°B	270.0	273.2	276.3	279.3	282.2	285.0	287.5	290.1
19	13	266.5	269.6	272.8	275.7	278.6	281.5	284.0	286.5
20	13.88-18°B	262.8	266.0	269.1	272.1	275.0	277.8	280.3	282.9
21	14	262.3	265.5	268.6	271.6	274.5	277.3	280.0	282.4
22	15	258.1	261.3	264.4	267.4	270.3	273.1	275.8	278.2
23	16	253.7	257.1	260.2	263.2	266.1	268.9	271.6	274.0
24	16.22-19°B	252.7	255.9	259.0	262.0	264.9	267.7	270.2	272.8
25	17	249.5	252.7	255.8	258.8	261.7	264.5	267.0	269.6
26	18.03-20°B	245.1	248.3	251.4	254.4	257.3	260.1	262.6	265.2
27	19	241.1	244.4	247.4	250.5	253.4	256.1	258.7	261.2
28	19.87-21°B	237.9	241.1	244.2	247.2	250.1	252.9	255.4	258.0
29	20	237.4	240.7	243.8	246.7	249.6	252.4	255.0	257.5
30	21	233.7	237.0	240.1	243.0	245.9	248.7	231.3	253.8
31	21.75-22°B	230.7	233.9	237.0	240.0	242.9	245.7	248.2	250.8
32	22	229.8	233.0	236.1	239.1	242.0	244.8	247.3	249.9
33	23.03-23°B	225.6	228.8	231.9	234.9	237.8	240.6	243.1	245.7
34	24	222.4	225.6	228.7	231.7	234.6	237.4	240.0	242.6
35	24.99-24°B	218.8	222.0	225.1	228.1	231.0	233.8	236.3	238.9
36	26	215.6	218.9	221.9	225.0	237.8	230.6	233.1	235.8
37	27	212.5	215.8	218.7	221.8	234.7	227.4	230.0	232.6
38	27.66-25°B	209.9	213.1	216.2	219.2	222.1	224.9	227.4	230.0
39	28	208.8	212.1	215.1	218.2	221.0	223.9	226.3	229.0
40	29	205.7	209.0	212.1	215.1	217.9	220.9	223.2	225.9
41	29.60-26°B	203.7	206.9	210.0	213.0	215.9	218.7	221.2	223.8
42	30	202.5	205.7	208.8	211.8	214.7	217.5	220.0	222.6
43	31-05.27°B	199.3	202.5	206.6	209.6	212.5	215.3	217.8	220.4
44	32	196.7	199.9	204.0	207.0	209.9	212.7	215.2	217.8
45	33	194.0	197.2	201.3	204.3	207.2	210.0	212.5	215.1
46	33.25-28°B	193.1	196.3	200.4	203.4	206.3	209.1	211.6	214.2
47	34	191.2	195.4	198.5	201.5	204.4	207.2	209.7	212.3
48	35	188.6	192.8	195.9	198.9	201.8	204.6	207.1	209.7

POWER PLANT ENGINEERING

CORRECTION FOR TEMPERATURE OF AQUA AMMONIA

The figures in top row indicate degrees Fahrenheit; those beneath give the strength of Ammonia at 60°.

Degrees Baume	60°	65°	67°	68°	72°	74°	76°	78°	81°	84°	88°	90°	92°	95°	96°	100°	102°	108°	109°
18	23¼	.....	.....	.....	.....	.....	23¼	23¼	23¼	23¼	23¼	23¼	23¼	23¼	23¼	23¼	23¼	23¼	23¼
19	22¾	.....	.....	.....	.....	.....	22¾	22¾	22¾	22¾	22¾	22¾	22¾	22¾	22¾	22¾	22¾	22¾	22¾
20	22¼	.....	.....	.....	.....	.....	22¼	22¼	22¼	22¼	22¼	22¼	22¼	22¼	22¼	22¼	22¼	22¼	22¼
21	21¾	.....	.....	.....	.....	.....	21¾	21¾	21¾	21¾	21¾	21¾	21¾	21¾	21¾	21¾	21¾	21¾	21¾
22	21¼	.....	.....	.....	.....	.....	21¼	21¼	21¼	21¼	21¼	21¼	21¼	21¼	21¼	21¼	21¼	21¼	21¼
23	.....	.....	.....	.....	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23
24	.....	.....	.....	.....	22¾	22¾	22¾	22¾	22¾	22¾	22¾	22¾	22¾	22¾	22¾	22¾	22¾	22¾	22¾
25	.....	.....	.....	.....	22¼	22¼	22¼	22¼	22¼	22¼	22¼	22¼	22¼	22¼	22¼	22¼	22¼	22¼	22¼
26	.....	.....	.....	.....	21¾	21¾	21¾	21¾	21¾	21¾	21¾	21¾	21¾	21¾	21¾	21¾	21¾	21¾	21¾
27	.....	.....	.....	.....	21¼	21¼	21¼	21¼	21¼	21¼	21¼	21¼	21¼	21¼	21¼	21¼	21¼	21¼	21¼
28	.....	.....	.....	.....	.....	.....	20¾	20¾	20¾	20¾	20¾	20¾	20¾	20¾	20¾	20¾	20¾	20¾	20¾
29	.....	.....	.....	.....	.....	.....	20¼	20¼	20¼	20¼	20¼	20¼	20¼	20¼	20¼	20¼	20¼	20¼	20¼
30	.....	.....	.....	.....	.....	.....	19¾	19¾	19¾	19¾	19¾	19¾	19¾	19¾	19¾	19¾	19¾	19¾	19¾
31	.....	.....	.....	.....	.....	.....	19¼	19¼	19¼	19¼	19¼	19¼	19¼	19¼	19¼	19¼	19¼	19¼	19¼
32	.....	.....	.....	.....	.....	.....	.....	.....	19	19	19	19	19	19	19	19	19	19	19
33	.....	.....	.....	.....	.....	.....	.....	.....	18¾	18¾	18¾	18¾	18¾	18¾	18¾	18¾	18¾	18¾	18¾
34	.....	.....	.....	.....	.....	.....	.....	.....	18¼	18¼	18¼	18¼	18¼	18¼	18¼	18¼	18¼	18¼	18¼
35	.....	.....	.....	.....	.....	.....	.....	.....	.....	17¾	17¾	17¾	17¾	17¾	17¾	17¾	17¾	17¾	17¾
36	.....	.....	.....	.....	.....	.....	.....	.....	.....	17¼	17¼	17¼	17¼	17¼	17¼	17¼	17¼	17¼	17¼
37	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	17	17	17	17	17	17	17	17	17
38	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	16½	16½	16½	16½	16½	16½	16½	16½	16½
39	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	16	16	16	16	16	16
40	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15½	15½	15½	15½	15½	15½
41	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15	15	15	15	15	15
42	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14½	14½	14½	14½	14½	14½

POWER PLANT ENGINEERING

STRENGTH OF AMMONIA LIQUOR

Percentage of Ammonia by Weight.	Specific Gravity.	Degrees Baume Water 10.	Degrees Baume Water 0.
0	1.000	10	0
1	0.993	11	1
2	0.986	12	2
4	0.979	13	3
6	0.972	14	4
8	0.966	15	5
10	0.960	16	6
12	0.953	17.1	7
14	0.945	18.3	8.2
16	0.938	19.5	9.2
18	0.931	20.7	10.3
20	0.925	21.7	11.2
22	0.919	22.8	12.3
24	0.913	23.9	13.2
26	0.907	24.8	14.3
28	0.902	25.7	15.2
30	0.897	26.6	16.2
32	0.892	27.5	17.3
34	0.888	28.4	18.2
36	0.884	29.3	19.1
38	0.880	30.2	20.0

The solutions of anhydrous ammonia in water are employed in the absorption machines, and the properties of such solutions vary with their strength or the percentage of ammonia which they contain. The strength of such solutions, "Ammonia liquor," as they are commonly called, is approximately determined by specific gravity scales or hydrometers, those of Baume being usually employed for this purpose.

PROPERTIES OF AMMONIA LIQUOR

135	140	145	150	155	160	165	170	175	180	Line
351.3	353.7	356.0	358.2	360.3	362.3	364.2	366.1	367.4	369.5	1
346.9	349.3	351.6	353.8	355.9	357.9	359.8	361.7	363.5	365.1	2
346.1	348.2	350.8	352.9	355.1	357.1	358.9	360.9	362.7	364.3	3
340.8	342.9	345.5	347.6	349.8	351.8	353.6	355.6	357.4	359.0	4
336.2	338.6	340.9	343.1	345.2	347.2	349.2	351.1	352.8	354.4	5
335.2	337.6	339.8	342.1	344.1	346.2	348.2	350.1	351.7	353.4	6
329.9	332.3	334.5	336.8	338.8	340.9	342.9	344.9	346.4	348.1	7
328.4	330.8	333.1	335.3	337.4	339.4	341.3	343.2	345.0	346.6	8
324.8	327.3	329.5	331.8	333.8	335.9	337.7	339.6	341.4	343.7	9
320.3	322.7	325.0	327.2	329.3	331.3	333.3	335.2	336.9	338.5	10
319.3	321.8	324.0	321.3	328.3	330.4	332.3	334.1	335.9	336.6	11
314.3	316.9	319.1	321.4	327.3	325.5	327.4	329.2	330.9	331.7	12
312.3	314.7	317.0	319.2	321.3	323.3	325.3	327.2	328.9	330.6	13
308.9	311.3	313.6	315.8	317.9	319.9	321.8	323.7	325.5	327.2	14
303.6	306.0	308.3	310.5	312.6	314.6	316.6	318.5	320.2	321.8	15
299.2	301.5	303.8	305.0	308.2	310.2	312.1	314.0	315.8	317.5	16
294.7	297.0	299.3	300.5	303.8	305.8	307.6	309.5	311.3	313.0	17
292.6	295.0	297.3	299.5	301.6	303.6	305.6	307.5	309.2	310.8	18
289.1	291.5	293.7	296.0	298.1	300.1	302.0	304.0	305.7	307.3	19
285.4	287.8	290.1	292.3	294.4	296.4	298.3	300.1	302.0	303.6	20
284.9	287.3	289.6	291.8	293.9	295.9	297.8	299.6	301.5	303.1	21
280.7	283.1	285.4	287.6	289.7	291.7	293.6	295.4	297.3	298.9	22
276.5	279.9	281.2	283.4	285.5	287.5	289.4	291.3	293.1	294.7	23
275.3	277.7	280.0	282.2	284.3	286.3	288.3	290.3	292.0	293.6	24
272.1	274.5	276.8	278.0	281.1	283.1	285.1	287.1	288.8	290.4	25
267.7	270.1	272.4	274.6	276.7	278.7	280.7	282.6	284.3	285.9	26
263.8	266.1	268.5	270.6	272.8	274.7	276.8	278.6	280.4	282.0	27
260.5	262.9	265.2	267.4	269.5	271.5	273.5	275.4	277.1	278.7	28
260.1	262.4	264.7	266.9	269.0	271.1	273.0	275.0	276.6	278.2	29
256.4	258.7	261.0	263.2	265.3	267.4	269.3	271.3	272.9	274.5	30
253.3	255.7	258.0	260.2	262.3	264.3	266.3	268.2	269.9	271.5	31
252.4	254.8	257.1	259.3	261.4	263.4	265.4	267.3	269.0	270.6	32
248.2	250.6	252.9	255.1	257.2	259.2	261.2	263.1	264.8	266.4	33
246.0	247.4	249.7	251.9	254.0	256.0	257.9	259.8	261.5	263.1	34
241.4	243.8	246.1	248.3	250.4	252.4	254.4	256.3	258.0	259.6	35
238.3	240.6	242.9	245.2	247.3	249.3	251.2	253.1	254.9	256.5	36
235.2	237.4	239.8	242.1	244.2	246.1	248.0	249.9	251.7	253.4	37
232.5	234.9	237.2	239.4	241.5	243.5	245.3	247.2	248.9	250.5	38
231.4	233.9	236.1	238.4	240.4	242.5	244.3	246.1	247.8	249.5	39
228.4	230.8	233.0	235.4	237.3	239.4	241.3	243.1	244.8	243.5	40
229.3	228.7	231.0	233.2	235.3	237.3	239.3	241.2	242.9	244.5	41
225.1	227.5	229.8	232.0	234.1	236.1	238.1	240.0	241.7	243.3	42
222.9	225.3	227.6	229.8	231.9	233.9	235.8	237.8	239.2	240.8	43
220.3	222.7	225.0	227.2	229.3	231.3	233.2	234.9	236.5	238.2	44
217.6	220.0	222.7	224.5	226.6	228.6	230.5	232.2	233.8	235.5	45
216.7	219.1	221.8	223.6	225.6	227.5	229.3	231.1	232.8	234.4	46
214.8	217.2	219.9	221.7	223.7	225.6	227.4	229.2	230.91	232.5	47
212.2	214.6	217.3	219.1	221.1	223.8	224.8	226.8	228.2	230.3	48

PROPERTIES OF AMMONIA LIQUOR

40	45	50	55	60	65	70	75	80	85	90	Line
282.8	288.1	292.9	297.5	301.9	306.3	310.4	314.4	318.2	321.8	325.2	1
279.4	283.7	288.5	293.1	297.5	301.8	306.0	310.0	313.8	317.4	320.8	2
277.6	282.8	287.7	292.2	296.7	300.9	305.2	309.2	312.9	316.6	320.0	3
272.3	277.5	282.4	286.9	291.4	295.6	300.0	303.9	307.6	311.3	314.7	4
267.7	272.9	277.8	282.4	286.8	291.1	295.3	299.3	303.1	306.7	310.1	5
266.7	271.8	276.7	281.4	285.7	290.1	294.2	298.3	302.1	305.6	309.1	6
261.4	266.5	271.4	276.1	280.4	284.8	288.9	293.0	296.3	300.3	303.8	7
259.6	264.8	270.2	274.8	279.2	283.5	287.7	291.7	295.5	299.1	302.5	8
256.1	261.2	266.7	271.2	275.6	280.0	284.1	288.2	291.9	295.5	299.0	9
251.8	257.0	262.1	266.7	271.1	275.4	279.6	283.6	287.4	291.0	294.4	10
250.8	256.1	261.1	265.8	270.1	274.5	278.6	282.7	286.4	290.1	293.5	11
245.9	251.2	256.2	260.8	265.2	269.6	273.7	281.7	281.5	285.2	288.6	12
244.2	249.3	254.1	258.7	263.1	267.4	271.6	275.6	279.4	283.0	286.4	13
240.8	245.9	250.7	255.3	259.7	264.0	268.2	272.2	276.0	279.6	283.0	14
235.5	240.6	245.4	250.0	264.4	258.7	262.9	266.9	270.7	274.3	277.7	15
231.0	236.1	240.9	244.5	249.9	254.2	258.4	262.4	266.2	268.8	273.2	16
226.4	231.5	236.4	240.0	245.4	249.8	253.9	257.9	261.7	264.3	268.7	17
225.0	230.3	234.4	239.0	243.4	247.7	251.9	255.4	259.7	263.3	266.7	18
221.4	226.8	230.8	235.5	239.9	244.2	248.4	251.8	256.2	259.8	263.1	19
217.6	222.7	227.2	231.8	236.2	240.5	244.0	248.7	252.5	256.1	259.5	20
217.1	222.2	226.7	231.3	235.7	240.0	243.5	248.2	252.0	255.6	259.0	21
212.9	218.0	222.5	227.1	231.5	235.8	239.3	244.0	247.8	251.4	254.8	22
208.7	213.8	218.3	222.9	227.3	231.6	235.1	239.8	243.6	247.2	250.6	23
207.2	212.3	217.1	221.7	226.1	230.4	234.6	238.6	242.4	246.0	249.4	24
203.9	209.1	213.9	218.5	222.9	227.2	231.4	235.4	239.2	242.8	246.2	25
200.7	205.7	209.5	214.1	218.5	222.8	227.0	231.0	234.8	238.4	241.8	26
196.8	201.7	205.6	210.1	214.6	218.8	223.1	227.0	230.9	234.4	237.9	27
192.5	197.5	202.3	206.9	211.3	215.8	219.8	223.8	227.6	231.2	234.6	28
192.1	197.0	201.9	206.4	210.8	215.2	219.3	223.4	227.1	230.7	234.1	29
188.4	193.3	198.2	202.7	207.1	211.5	215.6	219.7	223.3	227.0	230.4	30
185.3	190.3	195.1	199.7	204.1	208.4	212.6	216.6	220.4	224.0	227.4	31
184.4	189.4	194.2	198.8	203.2	207.5	211.7	215.7	219.5	223.1	226.5	32
180.2	185.2	190.0	194.6	199.0	203.3	207.5	211.5	215.3	218.9	222.3	33
177.0	182.0	186.8	191.4	195.8	200.1	204.2	208.3	212.1	215.7	219.1	34
173.6	178.6	183.2	187.8	192.2	196.5	200.7	204.7	208.5	212.1	215.5	35
170.4	175.5	179.9	184.7	189.1	193.3	197.5	201.6	205.3	208.9	212.2	36
167.2	172.4	176.7	181.5	185.9	190.2	194.3	198.4	202.2	205.7	209.0	37
165.1	170.3	174.4	178.9	183.3	187.6	191.8	195.8	199.6	203.2	206.6	38
164.0	169.3	173.3	177.9	183.2	186.6	190.7	194.8	198.5	202.2	205.6	39
161.0	166.2	170.2	174.8	180.2	183.5	187.6	191.8	195.4	199.1	202.6	40
159.0	164.3	168.1	172.7	178.1	181.4	185.6	189.6	193.4	197.0	200.4	41
157.8	163.1	166.9	171.6	176.9	180.2	184.4	188.4	192.2	195.8	199.2	42
154.5	159.8	163.6	168.3	173.5	177.0	181.2	185.2	189.0	192.6	196.0	43
151.9	157.2	161.0	165.7	170.9	174.4	178.6	182.6	186.4	190.0	193.4	44
149.2	154.5	158.3	163.0	168.2	171.7	175.9	179.9	183.7	187.3	190.7	45
148.3	153.6	157.4	162.1	167.3	170.8	175.0	179.0	182.8	186.4	189.8	46
146.4	151.7	155.5	160.2	165.4	168.9	173.1	177.1	180.9	184.5	187.9	47
143.8	149.1	152.9	157.6	162.8	166.3	170.5	174.5	178.3	181.9	185.3	48

HEAT OF ABSORPTION

The amount of heat developed by the absorption of one pound of ammonia in some cases of different strength of poor and rich liquor, together with the number of pounds of rich liquor that must be moved for each pound of ammonia evaporated in the refrigerator.

Ammonia in poor liquor, per cent.	Ammonia in rich liquor, per cent.	Heat of absorption of one pound of ammonia in units.	Pounds of rich liquor for each pound of active ammonia.
10	25	812	6.0
10	36	828	3.45
12	35 5	828	3.74
14	25	854	7.8
15	35	811	4.25
17	28.75	840	7.0
20	25	840	16.0
20	33	819	6.1
20	40	795	4.0

CORRECTION FOR TEMPERATURE OF AQUA AMMONIA (CONTINUED)

	00°	64°	65°	66°	70°	72°	75°	76°	80°	84°	85°	90°	92°	95°	96°	100°	104°	105°
23¼	23¼	.....	23½	.....	23¼	.....	23	.....	22¾	.....	22½	22¼	.....	22	.....	21¾	.....	21½
24	24	.....	23¾	.....	23½	.....	23¼	.....	23	.....	22¾	22½	.....	22¼	.....	22	.....	21¾
24¼	24¼	.....	24	.....	23¾	.....	23½	.....	23¼	.....	23	22¾	.....	22½	.....	22¼	.....	22
24½	24½	.....	24¼	.....	24	.....	23¾	.....	23½	.....	23¼	23	.....	22¾	.....	22½	.....	22¼
24¾	24¾	.....	24½	.....	24¼	.....	24	.....	23¾	.....	23½	23¼	.....	23	.....	22¾	.....	22½
25	25	.....	25	.....	24½	.....	24¼	.....	24	.....	23¾	23½	.....	23¼	.....	23	.....	22¾
25¼	25¼	.....	25¼	.....	25	.....	24½	.....	24¼	24	24	23¾	.....	23½	.....	23¼	.....	23
25½	25½	.....	25½	.....	25¼	.....	25	.....	24½	24½	24¼	24	.....	23¾	.....	23½	.....	23¼
26	26	.....	25¾	.....	25½	.....	25¼	.....	25	25	24½	24¼	.....	24	.....	23¾	.....	23½
26¼	26¼	.....	26	.....	25¾	.....	25½	.....	25¼	25¼	25	24½	.....	24¼	.....	24	.....	23¾
26½	26½	.....	26¼	.....	26	.....	25¾	.....	25½	25½	25¼	25	.....	24½	.....	24¼	.....	24
26¾	27	.....	26½	.....	26¼	.....	26	.....	25¾	25¾	25½	25¼	.....	25	.....	24½	.....	24¼
27	27¼	.....	26¾	.....	26½	.....	26¼	.....	26	26	25¾	25½	.....	25¼	.....	25	.....	24½
27¼	27½	.....	27	.....	26¾	.....	26½	.....	26¼	26¼	26	25¾	.....	25½	.....	25¼	.....	25
27½	27¾	.....	27¼	.....	27	.....	26¾	.....	26½	26½	26¼	26	.....	25¾	.....	25½	.....	25¼
27¾	28	.....	27½	.....	27¼	.....	27	.....	26¾	26¾	26½	26¼	.....	26	.....	25¾	.....	25½
28	28	.....	27¾	.....	27½	.....	27¼	.....	27	27	26¾	26½	.....	26¼	.....	26	.....	25¾

The specific gravity of aqua ammonia changes with the temperature at which it is measured with the hydrometer. The readings are too high if the temperature of the ammonia is over 60° F., and too low if under. To ascertain the exact strength of ammonia at 60° F., make the corrections for temperature in accordance with the table, thus: 26¼° ammonia, measured at a temperature of 80° F., is equal to 25¾° ammonia at a temperature of 60° F.

CRANE CO.

J. B. HOWELL, of the sales department of the Bound Brook Oil-Less Bearing Co., has entered active service in the United States Army, and is now training at Camp Dix.

THE WESTINGHOUSE ELECTRIC & MFG. CO. announces the removal of its offices from Phoenix, Arizona, to Tucson, Arizona. Its representatives, Messrs. J. H. Knost and W. G. Willson, will have headquarters in the Immigration Building at the latter point.

W. H. THOMPSON, for many years prominent in the heavy electric traction work of the Westinghouse Electric & Mfg. Co., has resigned to accept the position of Works Manager of the Fairmont Mining Machinery Co., of Fairmont, W. Va., makers of coal mining equipment.

F. G. ROLLINS, late president and general manager of the Holmes Metallic Packing Co., of Wilkes-Barre, Pa., died at his home in Philadelphia on Wednesday, Feb. 20.

Mr. Rollins was born in Springfield, Mass., on Aug. 21, 1861, and lived there until about 15 yr. ago, when he became associated in business with his father at Wilkes-Barre, succeeding his father as president and general manager of the Holmes Metallic Packing Co., in December, 1915, when his father died.

Mr. Rollins is survived by his wife, one grandchild, G. Dayton Rollins, of Brooklyn, N. Y.; his mother, Mrs. Geo. D. Rollins, and one sister, Mrs. A. C. Ayres, both of Philadelphia.

ADAM COOK, the senior member of the firm of Adam Cook's Sons, manufacturers of Albany Grease, died on Feb. 19, 1918, at his residence, 148 W. 78th St., New York City, after an illness extending over a period of seventeen weeks. Adam Cook was born in Albany, N. Y., in 1867, and was a graduate of the Albany Military Academy. He became a member at an early age of the firm of Adam Cook's Sons, which his father, Adam Cook, founded at Albany, in 1868.

ON FEB. 23, the stock of the Schutte & Koerting Co. was transferred to the Alien Property Custodian of the United States, and at his instance the Board of Directors was reconstructed to include E. Pusey Passmore, Ralph J. Baker, D. W. Hildreth, T. H. Johnston and Chas. S. Calwell. The new Board elected the following officers: Chas. S. Calwell, president; D. W. Hildreth, treasurer, and Ralph J. Baker, secretary. This ensures the active continuation of the business of the Schutte & Koerting Co. in all lines, to full capacity.

Catalog Notes

A NEW VALVE CIRCULAR has been received from The Ohio Brass Co., Mansfield, Ohio.

BABBITT adjustable sprocket rim, manufactured by Babbitt Steam Specialty Co., New Bedford, Mass., is illustrated and described in the company's latest folder.

CHAIN DRIVEN Motor Trucks and Tractors, the latest publication, No. 359, of Link-Belt Co., 39th St. and Stewart Ave., Chicago, was recently issued.

USES OF VULCANIZED FIBRE are illustrated in a folder lately received from Wilmington Fibre Specialty Co., Wilmington, Del.

AIRSPRING compressed air grease cups, made by Hunter Pressed Steel Co., of Philadelphia, are described in a book recently issued by the company.

NEW FOLDERS from Yarnall-Waring Co., of Philadelphia, deal with the Simplex "Seatless" blowoff valve and Simplex pipe-joint clamp.

THE FOLLOWING LEAFLETS were lately received from Thomas Grate Bar Co., Birmingham, Ala.: Form P. 112, on the subject of Thomas elliptic grate bars, shaking, circle and stationary, for every fuel; Form P. 212, on Thomas elliptic grate bars for contractor's equipment; Form P. 312, Thomas elliptic grate bars for steamships.

SUPERSTEAM SERVICE is the title of a booklet published by Strong Engineering Co., 570 W. Monroe St., Chicago, discussing the use of highly superheated, high or low pressure steam in power and industrial plants, and illustrated by diagrams.

NASH HYDRO-TURBINE air compressors and vacuum pumps are the subject of Bulletin No. 7 of Nash Engineering Co., South Norwalk, Conn.

Another circular from that company describes Jenning's turbine vacuum and low pressure boiler feed pumps for return line heating systems and paper mill dryer exhaust systems.

SAFETY AUTO-LOCK SWITCHES are described and illustrated in some detail in special publication No. 1585-A just issued by the Krantz Mfg. Co., Inc., of Brooklyn, N. Y.

These switches are designed for use on circuits wherever the ordinary knife switch may be applied. They are especially designed for safety, so that it is absolutely impossible to touch the live parts regardless of the position of the switch or of the door.

They are particularly adapted for use in steel mills, factories, mines and other similar locations where men are employed who have no practical knowledge of electricity.

THE AMERICAN Exporter Translation Bureau has begun the publication of an "Exporters' Ready Reference Series" consisting of a series of pamphlets containing tables of equivalents of American measurements into Metric or Russian measures, conversion formulas and information concerning exporters' linguistic problems, together with a variety of notes concerning languages and foreign customs.

The following numbers have already come from the press:

No. 1. Conversion of pounds into kilos. Countries in which metric measurements are obligatory. No. 2. Conversion of inches into centimeters. Principal languages of the world. No. 3. Conversion of feet into meters. The brevity of English. No. 4. Conversion of

(Continued on page 268.)

Come on Men 25,000 of You!

Launch a Blow at the Kaiser by Helping Launch a Ship

Who says we can't build ships!

Come on you loyal American Mechanics, masters of familiar trades, and brand this "made in Germany" insinuation by building a bridge of ships to Pershing.

You can't do your country a greater service than by exchanging your good American brawn and skill for good American dollars — in the shipyard. And you'll do as much to win the war as the men dependent upon you in the trenches. Ships, men, are the pivot on which the destiny of this country turns, and Uncle Sam is looking for 250,000 U. S. shipyard volunteers to build them.

Listen!

Every rivet driven in the shipyards brings us nearer to the successful termination of the war.

To do our fair share our shipbuilding program calls for 6,000,000 tons a year, or over a thousand ships. We must have them to win. We must have them to keep the wheels of American industry moving and American labor employed in the factories.

The Man of the Hour

The shipping Board has the money, the materials and the yards to carry out this 6,000,000 ton program, but it needs men to assure these thousand yearly launchings which will hurl their tidal wave toward Germany. There must be an immense reserve of earnest skilled labor to draw on as fast as plants are completed in the yards and housing provided.

This, then, is the purpose of this message—to ask your enrollment as a shipyard volunteer, for work in the shipyards when needed. Back up Uncle Sam and the millions of your brother workmen by your enrollment.

This does not mean that you are to give up your regular job and rush off to some shipyard which at the moment, may not be able to accommodate you. Quite the contrary! Your enrollment simply shows that you stand ready, when called upon, to do a particular job for a particular wage in a particular place. Every thing will be in readiness for you, and you will lose no time.

"But," you say, "I've never worked on shipbuilding."

That's exactly why Germany thinks that America cannot build ships. Germany knows that

there are not enough men in America who have actually worked on ships to make more than a tenth of the ships we need if we are to do any fighting worth while.

Here is where you American workmen can fool the Kaiser.

Ships are not things of mystery; they are merely big buildings afloat — the product of everyday skill and industry—and the American Mechanic (hats off to him) can build them.

Familiar trades—**your** trade—are the ones that build ships; and almost all trades are represented. Two-thirds of the occupation used in shipbuilding are common to other industries, like boiler making, car building, bridge building, carpentering, machine shop work, etc. The list given later indicates some of the classes needed. Read it carefully and see how you qualify.

This Is Your Badge of Honor
Wear It Proudly

If you possess the **right** sort of training now is the time to rally around this movement and wear a Badge of Honor. This button, issued by the United States Shipping Board, shows that the wearer, through enrollment in the United States Shipyard Volunteers, has placed the welfare of the Nation above all else and stands ready by his labor to help throw across the seas a bridge of ships by which the armies of the United States can pass to do their duty on the fields of France.

To wear this button is a sign of distinction. It truly stamps the owner as the **man of the hour** in whose hands rest the happiness and security of every man, woman and child in this country.

Come on men—250,000 of you! Your Government is asking that you answer the rattle of German machine guns with the rattle of the riveter. It is asking you, for the present, to prove that you are the marrow of Americanism by going on record with an expression of your willingness to help build ships where you are needed. And it meets you half-way with good wages and with all honor.

Can you turn a deaf ear to the call? Where can **you** qualify in the following list?

Acetylene and electrical welders
Asbestos workers
Blacksmiths
Anglesmiths
Drop-forge men
Flange turners
Furnace men
Boiler makers
Riveters
Reamers
Carpenters
Ship carpenters
Dock builders
Chippers and calkers
Electrical workers
Electricians
Wiremen
Crane operators
Foundry workers
Laborers, all kinds
Loftsmen
Template makers
Machinists and machine hands, all sorts
Helpers
Painters
Plumbers and pipe fitters
Sheet-metal workers
Coppersmiths
Shipfitters
Structural iron workers
Riveters
Erectors
Bolters up
Other trades
Cementers
Cranemen

Clip the Coupon and Get the Full Story

Edward N. Hurley, head of the United States Shipping Board, is the mouthpiece of Uncle Sam in this call for shipyard volunteers. He has complete information on hand, ready to mail you, regarding method of enrollment and other details you may want to know. The coupon below is here for your convenience in writing. Don't delay. Fill in the information asked for, clip and mail. Your action in this matter will bring you full particulars.

Show that you are **interested** by doing this now, while the coupon is before you.

Edward N. Hurley, Chairman,
U. S. Shipping Board,
Washington, D. C.

I wish you would send me at once further information, telling me how I can enroll as a member of the U. S. Shipyard Volunteers of the Public Service Reserve for employment in shipyards and so help win the war.

My Trade is.....

My Name is.....

Street Address.....

Town..... State.....

miles into kilometers. Number of words in various languages. No. 5. Conversion of miles into Russian Verst. Nationalities and languages in Russia. No. 6. Conversion of gallons into Russian Vedro. Transliterations of Russian print. No. 7. Conversion of pounds into Russian Funt. Russian weights and measures. No. 8. Conversion of yards into meters. Countries without a national language. No. 9. Conversion of gallons into liters. Difficulties of technical translations. No. 10. Conversion of inch fractions into millimeters. Idiomatic and Dictionary Translations. No. 11. Metrical equivalents of wire gages. Etymological Translations. No. 12. Conversion of ounces into grammes. Sounds and accents.

This series, will, when complete, comprise 24 booklets in all.

Trade Notes

THE WESTINGHOUSE Electric and Mfg. Co., of East Pittsburgh, Pa., has recently secured the exclusive sales agency for the United States for Frankel solderless connectors, widely used for joining electrical wires and cables. Manufacturing facilities have been increased by the Frankel Connector Co., in order to care for the new business to be secured through the Westinghouse sales organization.

The Westinghouse Co. will act also as a distributor of Frankel testing clips.

IN JANUARY, the St. Louis branch of the H. W. Johns-Manville Co. moved into its new building, with 55-ft. front on Olive Street and 109-ft. on Eleventh Street. The company will occupy the entire six floors and basement. The new quarters give space for a show room 55 by 72 ft. for the convenience of customers, ample offices on the second floor for manager and selling departments, accounting, purchasing and traffic departments on the third floor, and the other floors for stock and shipping rooms, and manufacturing departments. Full stocks of all the company's products will be carried for quick delivery to the territory supplied from this branch.

SUGGESTION IS MADE by a chief engineer, who has had experience, in regard to stopping and preventing leaky joints in piping.

He says: "I haven't a leaky joint in our plant now, and I expect never to have any more. I tried Graphite Pipe Joint Compound on flange and screw joints and on all bolts, shanks as well as threads. The compound on shanks makes the bolts easier to drive as well as preventing rusting in, and the nuts can be pulled up easier and better.

"I have found that you can make a tighter and better joint, and that the Dixon Compound does not harden so that the joint can be opened easily at any time. I have heard that the joints have been opened after 20 yr., without difficulty; and a friend told me that a 15-in. gas main in Reade St., New York, was easily opened after being buried a number of years, although they had expected a lot of trouble with it. That surprised the gas people, so that they investigated, and have adapted the Dixon's Graphite Pipe Joint Compound as standard for joints. So I decided, why shouldn't I use it?"

POWER PLANT ENGINEERING

Trade-mark, Reg. U. S. Pat. Off.

(Established over 22 years.)

PUBLISHED THE FIRST AND FIFTEENTH OF EACH MONTH

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Subscription price in advance in the United States, Mexico or united possessions, $1.00 a year.

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Address all letters and make all checks and money orders payable to Technical Publishing Co., 537 S. Dearborn St., Chicago, Ill.

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Member Audit Bureau of Circulations.

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Full page, one year, each insertion, $66.00.

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Other specified positions, regular rate plus 10 to 50 per cent.

Three line parallel 3-point border rule used.

Stippled plates used, but no heavy, black and white plates.

CLASSIFIED ADVERTISING RATES

Per line, 30 cents each insertion.

Advertisements in this section are inserted under regular headings.

No display type allowed, but the first three words may be set in capital letters.

About nine words make a line. Minimum space sold, two lines.

Under classification "Position Wanted," advertisements not exceeding four lines will be inserted once for subscribers free of charge.

All copy and cuts should be received at Chicago Office eighteen days prior to date of publication.

Circulation of this issue, 23,450.

Technical Publishing Company

537 S. Dearborn Street

Chicago

Position Wanted

POSITION WANTED—By engineer experienced with producer gas and oil engines, a.c. and d.c. equipment, pumps, storage batteries, interior wiring and repair work. Technical graduate. References. Address Box 501, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 1-1-1

POSITION WANTED—By experienced fireman and engineer who has had charge of waterworks plants, and effected saving of half the coal bill by overhauling the plant. Familiar with electrical work. Address Box 507, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 2-15-1

POSITION WANTED—Power station draftsman, electrical graduate, experienced in power and substation layout work. Six years in present position with large manufacturing concern. Desires change. Address Box 511, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 3-1-2

POSITION WANTED—By a practical high- and low-pressure pipe fitter. Age 35 years. Would like to become connected with reliable concern as general pipe fitter or foreman. Address Box 512, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 3-1-4

POSITION WANTED—By a competent electrician and engineer; 34 years of age; married; strictly sober and energetic. Willing to take complete charge of electric light plant or will take charge of power installation or operation. Present salary $150. Desire change with larger opportunity. Address Box 515, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 3-15-1

Help Wanted

WANTED—Resident subscription agents in the following cities: Atlanta, Ga.; Cincinnati and Columbus, Ohio; Kansas City, Mo.; Los Angeles, Cal.; Louisville, Ky.; Newark, N. J.; New Orleans, La.; Portland, Ore.; St. Louis, Mo.; San Francisco, Cal.; Washington, D. C. This is an excellent chance for a hustler, who is familiar with power plant conditions, to turn his spare time into dollars. To such a one we offer a Real Opportunity. Write Subscription Department, Power Plant Engineer, 537 S. Dearborn St., Chicago, Ill. tf.

BOILER HOUSE MECHANIC WANTED—A good mechanic, to act as general boiler room repair man in large mill out of town. Must be familiar with machinery, boilers, stokers, etc. State age, married or single, experience and enclose copy of references. Address Box 510, Power Plant Engineering, 537 S. Dearborn St., Chicago. 2-15-3

WANTED—A competent refrigerating engineer in Western Pennsylvania. Must be familiar with raw water and ice making system and electric machinery. State salary wanted. Address Box 505, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. tf.

Wanted

WANTED—Agents on commission to sell our shaking grates. We will install grates on trial to put it to test at our expense with any grate made. Address Armstrong Mfg. Co., Springfield, Ohio. tf.

WANTED—Agents handling engine and boiler room specialties in every section for side line paying large commissions. Give experience, line carried and territory covered. Box 381, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. tf.

WANTED—Marine boilers. We will pay cash awards for information that leads to a purchase by us of marine boilers of from 75 hp. to 250 hp. The Pittsburg Boiler & Machine Co., Pittsburg, Kan. tf.

WANTED—Agents handling engine and boiler room specialties in every section of our Boiler Girth Seam Protector. Liberal inducements. Give experience and territory covered. Address National Boiler Protector Co., Dayton, Ohio. tf.

WANTED—Kelley's Engineer's Examiner. Anyone having a copy of this which he will sell please write, giving price and condition. Address Box 516, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 3-15-1

ENGINEERS CAN EARN money during their spare time, increase their knowledge, their salaries and their value to their employers by taking advantage of our proposition. Write today. Address Box 517, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 3-15-1

WANTED—Engineers in their spare time and salesmen who carry side lines and visit engineers to sell the Selden and Zena packings. Both packings have shown their worth by use in largest plants. Randolph Brandt, 70 Cortlandt St., New York. 3-15-6

For Sale

FOR SALE—125- volt d.c. units:

Kw.	Generator	Engine	Price
100	Al. Chal.	Watertown	$1900
75	G. E.	Harrisburg	1800
65	C. & C.	Harrisburg	1500
50	Wghse.	Harrisburg	1350

Power Machinery Exchange, Inc., Jersey City, N. J. tf.

ELECTRICIANS—Send $1.50 for 16 blue prints of Motor Windings, 12 A.C. Single, two and three-phase and 6 D.C. or set of 24 A.C., 6 D.C. and 6 Rotary Converter Drawings for $2.25. Connecting and Winding made easy. Superior Electric Co., Lock Box 1372, Pittsburgh, Pa. 3-15-2

FOR SALE—BOILERS. Two 150 hp. H. R. T. Boilers, butt strapped construction, 120 lb. pressure, $1000 each. 400 hp. Atlas Watertube Boiler with Murphy Stoker and Superheater, built for 210 lb. pressure, 4 years' service, $5000. Power Machinery Exchange, Inc., Jersey City, N. J. tf.

FOR SALE—One 306 hp. Double Drum, and one 225 Single Drum Heine Boiler; one Model Stoker for 360 hp. and one for 225 hp. boiler; one 160 hp. and one 100 hp. Tandem Compound Skinner Auto Engine; one Lagonda Tube Cleaner; one Pneumatic Hammer; one 14 in. 54 ft., one 14 in. 45 ft., one 12 in. 53 ft., one 12 in. 45 ft. Double Leather Belts, Endless; two 4 in. Austin, and one 4 in. Cochrane Steam Separator; one 8 in. Back Pressure Valve; one Westinghouse Standard 11 in. Air Compressor, Water Jacketed with Tank and Accessories; one 8 in. Oil Separator; one 300 hp. Warren-Webster Exhaust Open Heater; seven 8 in. Gate Valves; one American Water Softener, 1500 gal. per 24 hrs.; three 4 in. Pop Safety, eight 4 in. Gate, and one 4 in. Angle Valve; one 7 in. Exhaust Head. All this material is in good running order and is in service now. The Busy Bee Candy Kitchen Co., 44 N. Front St. Columbus, Ohio. 3-1-2

Patent and Patent Attorneys

PATENTS THAT PROTECT AND PAY—Advice and books free. High references. Best results. Promptness assured. Send sketch or model for search. WATSON E. COLEMAN, Patent Lawyer, 624 F St. N. W., Washington, D. C. tf.

PATENTS—C. L. Parker, Attorney-at-Law and Solicitor of Patents. Patents secured promptly and with special regard to the legal protection of the invention. Handbook for inventors sent upon request. Washington, D. C. tf.

PATENTS—H. W. T. Jenner, Patent Attorney and Mechanical Expert, 606 F St., Washington, D. C. Established 1883. I make a free examination and report if a patent can be had and the exact costs. Send for full information. tf.

A. P. CONNOR, Consulting Electrical and Mechanical Engineer, Attorney-at-Law and Solicitor of patents and Trade-Marks. Results guaranteed. 121 Carroll St., S. E., Washington, D. C. tf.

PATENTABLE IDEAS WANTED—Send for three free books. R. B. Owen, 28 Owen Bldg., Washington, D. C. tf.

Technical Books

FREE ENGINEER BOOKS and power plant tools and specialties, for securing new subscribers for Power Plant Engineering. A dandy chance for the engineer with a little spare time to get some fine premiums. Send for free descriptive circular and terms. Subscription Department, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill.

Miscellaneous

FACTORY MANAGERS, ENGINEERS AND OWNERS—Coal is high and scarce. Let us tell you how to conserve it and utilize your exhaust steam for heating and drying purposes. Address Monash Engineering Co., 1413 W. Jackson Boulevard, Chicago, Ill. tf.

YOU CAN SAVE 10 to 50 per cent of your coal bill by utilizing exhaust steam to heat boiler feed water, to warm buildings, to dry materials, etc., and by keeping the boilers free of soot and scale, stopping up air leaks in boiler settings, repairing baffles, adopting more scientific methods of firing and regulating draft and purchasing your coal more intelligently. The latest and best data on steam plant economy has been specially compiled for the use of owners, manager, designers, engineers and firemen in the Cochrane Coal Savers' Manual, "Finding and Stopping Waste in Modern Boiler Rooms"; 274 pages, 213 charts and diagrams, bound in flexible cloth; price $1.00. Harrison Safety Boiler Works, 3144 N. 17th St., Philadelphia, Pa. 3-15-3-E.O.1

Sparks From The Advertising Pages

Where Buyers and Sellers Meet

Stop the Leaks!

Battles are not won by guns alone. The powder that is selected, the cleaning they are given, and the way they are aimed—each is as important as the gun itself.

Horsepower is not the result of the engine alone. The coal that is burned, the grates that burn it, the valves, the packing, and above all the intelligence that selects and controls these factors, build horsepower efficiency.

Battles are being won in the boiler rooms as well as in the trenches. The firing line in France and in your power plant are interdependent.

Your usefulness lies in your ability to buy wisely, to apply your knowledge so that break-downs will not occur.

Only **then** is efficiency possible.

Your country is calling upon you now to furnish MORE than the usual "10 per cent available energy" from the coal you burn.

It must be 11, 12, 15 per cent!—else we fail to do our part.

Now, as never before, you must buy and apply the **right** equipment for the **right** use. Mistakes are as dangerous as misfires. Always costly—they now verge on treason. The product which can not prove its worth should get no consideration.

Our country calls for every foot-pound of work you can produce, every erg of energy you can conserve.

Each squeak of metal against metal, every escaping puff of steam, is a contribution to the war chest of the Hohenzollerns.

STOP THE LEAKS!

The Chief Engineer who buys the products advertised in POWER PLANT ENGINEERING is best equipped to fight the battle against waste. Its pages will help him to do his full duty—to his country, to his firm, as well as to himself.